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FOR THE

PROMOTION OF THE MECHANIC ARTS.

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EDITORIAL.

ITEMS AND NOVELTIES.

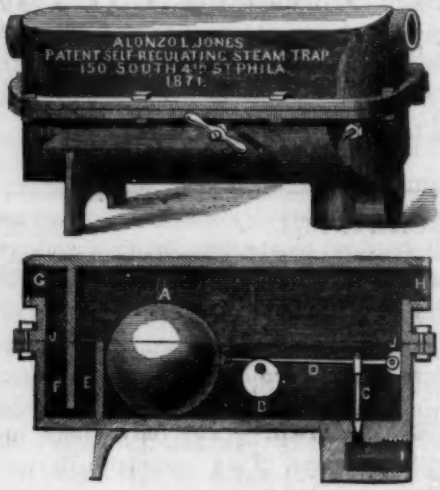
Jones' Self-regulating Steam Trap.—The advantage in many instances, and the necessity in some, of an automatic device by which the water of condensation can be discharged from the end of a coil of heating pipes as fast as formed, without allowing the escape of steam, or by which an engine at a considerable distance from the boiler can be relieved from the injurious effects resulting from working water through it, are too well known and too generally appreciated to require comment.

The means generally used to this end have depended upon the differential expansion of metals, but though machines constructed upon this plan in some instances answer pretty well at first, they are constantly liable to fail, owing to the well-known fact that, after some time, metals cease to expand and contract regularly under changes of temperature to which they have become accustomed. The force of gravity has also been used by means of a ball-float, to which is attached a valve, and which, rising as the chamber in which it is contained fills with water, raises the valve and allows the water to escape as fast as it enters the chamber. These are liable to two objections: first, that the balls cannot be made sufficiently large to be able to lift

against any considerable pressure of steam a valve large enough to relieve pipes in which water condenses rapidly without losing the strength necessary to prevent collapse, and, second, that the balls, which practically cannot be made entirely tight, gradually fill and become water-logged.

The instrument now under consideration provides against these difficulties in the following manner.

It consists of a cast-iron box, having inlet and outlet pipes, and containing a ball-float attached to a lever, which, at the other end moves upon a pivot, and to which, near the pivot, is suspended a valve. The lifting force of the ball being thus supplemented by this leverage, it is able to open a valve sufficiently large without expansion to an impracticable size; still it is liable to leakage, to counteract which the lever is made hollow; the pivot upon which it moves is a hollow T, into which it is screwed. One end of the T is plugged and into the other end is screwed a small tube which passes out through the side of the trap through a stuffing-box. Thus while the ball is free to move with the rise and fall of the water, a free passage is always maintained from the inside of the ball to the outer air. The ball being under steam pressure must be always at a temperature exceeding 212°, and any water that may leak into it being only under atmospheric pressure, must be instantly evaporated and the ball must be kept empty. When steam is first turned on to a coil of pipes, it is desirable to relieve them of the contained air, to do which the ball and valve are temporarily raised by a cam under the lever, whose axis passes through a stuffing-box to a handle outside, and to prevent freezing, should there be danger of it when the steam is turned off, the valve is opened by the same cam and the trap is drained.



Fire Extinguisher for Ships.—A suggestion of Dr. Schuppert, of New Orleans, for the purpose of extinguishing fires on ship-

board, seems practical enough to merit reproduction. According to his plan there are to be placed at given points, in the hold of the vessel, boxes, furnished with a supply of marble waste. Each box is to be brought into communication with the deck of the vessel by means of lead pipes, terminating in a funnel or other convenient manner. Should a fire be discovered in the hold, sulphuric acid is poured down the pipes; and this, coming in contact with the marble, causes the active evolution of carbonic acid gas, which finds its way in quantity with the hold, through perforations in the boxes, surrounding the cargo with an atmosphere which is a non-supporter of combustion. As the carbonic acid gas is much heavier than the air, it is anticipated that it will not escape in any considerable quantity until the hold is filled to overflowing.

Jordan's Steam Trap.—In mines, rolling mills, and wherever steam has to be carried some distance through pipes from boilers to engines, pumps, etc., many accidents occur from the water arising from condensation of steam getting into the cylinders, etc. In such cases the use of an effectual steam trap is a desideratum. The following is a description of a machine similar in construction to the globe valve, consistitg of an iron body or case, 24 inches long, with a brass seat for an inch valve, which valve is attached to a brass perforated tubular stem, the upper end being threaded and held in place by passing through a cap, like the stem of a globe valve. By this means it can be opened and shut like a valve, or set to work by the difference of expansion of the iron body and the brass valve stem, steam heat shutting it and the lower temperature of the water of condensation opening it. The opening being proportioned to the temperature, when there is great condensation and the water colder, the valve is wider open, as there is more water to discharge. It is claimed for this trap that it is of very superior quality, with regard to quickness of action, amount of water discharged, in prevention of loss of steam, and in being non-freezing.

A New Application of Steam Power.—The *Dental Cosmos* contains a communication from Dr. J. Frederick Babcock, in which the writer states that he has for the first time and successfully employed steam power in dentistry, and heartily recommends its use to his

professional brethren. The motor employed is the "Morrison Engine," for which special advantages to this end are claimed. Referring to the character of the work, the writer says: "The action of the drills is much more perfect, being made steadier. The speed is more fully under control, and may be made very much greater or very much slower than is possible by foot power. The treadle is abolished and, of course, the tiresome action of the foot and leg with it. The operator has as perfect control over his body as though he were doing nothing in the way of work. * * * Every operation performed upon the teeth, excavating, putting in the gold, finishing, polishing, separating, etc., I now do by steam power."

The Canal in Winter.*—When Mr. Robert Chesebrough published his scheme for keeping canals open in winter by warming the water, his project was received with such general ridicule, that we believe this journal stood alone in granting its author the possession even of common sense. But Mr. Chesebrough has now published a second pamphlet containing opinions by Prof. Thurston and Dr. Van der Weyde upon his scheme, and they both take ground similar to our own—that is, that the plan proposed is no way deserving of ridicule, but does fairly merit careful investigation. Prof. Thurston has gone into the subject very carefully and comes to the conclusion, also independently expressed by us, that the problem contains elements which have never been determined, and which are worthy of attention. These questions are: the amount of ice which forms during the winter, the amount of protection it affords the fluid water, the effect of boats keeping the thin ice broken up, etc. Eliminating all but the first of these, and estimating that the average thickness of ice formed in the Erie canal during the winter at two feet, he finds that one mile of canal, 35 feet wide, would be covered with 369,600 cubic feet of ice; and this would require 3,020,001,600 British thermal units to melt it. A ton of anthracite containing 90 per cent. of carbon and giving out 75 per cent. of heat produced, would yield 10,000 thermal units, so that the ice on one mile of canal would be melted by 302,000 lbs. of coal, or 138.8 tons; allowing, also, 10 per cent. for loss of heat in warming the water, he arrives at the round number of 150 tons per mile. His estimates, therefore, differ from those of Mr. Chesebrough, and in their financial calculations they separate still more widely. Prof. Thurston points out that the in-

*From the *Engineering and Mining Journal.*

tensity of cold in winter is not a regular thing, and that the apparatus must be made large enough to answer for the coldest days. This increases the first cost to $12,000 per mile, and the running expenses are estimated at $3,520 per mile. This is for a canal of 35 feet wide. If the prism is made 70 feet wide, as proposed, the expense will not be doubled, but will amount to $22,500 for plant and $6,305 for running expenses.

These items are, however, modified by various considerations. Thus, steamers are used as ice breakers, and if they are supplied with condensing engines they would act as moving ice melters as well as ice breakers. If canal boats are to be propelled by steam, a proposition which is extremely probable, they could by law be compelled to use condensing engines, and by their number they would contribute very materially to the amount of heat supplied to the water. Their movements, too, would have an important effect in breaking up the ice, so that a whole fleet proceeding along the canal could make its way at an expense which would not be great for any one boat. In fact, ice does not form so readily in agitated water as in still water, and thus the boats would contribute a mechanical means of preventing the formation of ice.

Taking all these points into consideration, Prof. Thurston says: "If the capacity (of the heating apparatus) were such that it would be capable of destroying ice one inch thick in twenty-four hours, or possibly even somewhat less, the steam ice-breakers would be able, at comparatively moderate expense, to keep the channel open in all but the coldest days of the winter, until the extreme cold weather had passed, and thus the heating apparatus could be given more nearly a capacity for average work as proposed, its expense would be correspondingly reduced and the total expenditure per annum would approximate to a maximum. The favorable circumstances already described would in this case also find their fullest development. Proceeding on this basis, which should be regarded simply as representing my individual views, my estimates would become for a canal 70 feet wide:

Cost of plant per mile:

Heating apparatus	$12,000
Distributing apparatus	2,500
Buildings and land	1,250
Total	$15,750

Cost of maintenance per mile and per annum:

Repairs and depreciation	$1,450
Interest on capital	1,102
Coal—300 tons at $4	1,200
Two men—three months, at $60	360
One man—four months, at $60	240
One man—three months, at $90	270
Superintendent and contingencies	150
Total	$4,772

Total estimates for canal 350 miles long, 70 feet wide, in the latitude of central New York:

First cost, 350 miles, at $15,750	$5,412,500
Maintenance per annum, 350 miles, at $4,772	1,670,200

Professor Thurston, as we said before, thinks the scheme deserves investigation, and that an engineer of proper ability would be able to determine the doubtful points without difficulty and at very moderate cost.

Mr. Chesebrough dissents from the estimates of Professor Thurston, but these financial questions are not at present the interesting ones. Enough has been shown to warrant a full trial of the project. He makes a new suggestion, however, upon which we will have a word to say. It is, that ice might be prevented from forming by pouring petroleum on the water, a thin film of this fluid being an effectual preventive of ice; also that if thick ice forms during a cold snap, it can be made very rotten by burning benzine on the surface. Unfortunately, there is experience on record of rivers covered by petroleum, and this experience is not of a kind which can encourage its intentional use. A canal that is lined in every mile of its length with buildings and boats that are too valuable to be lightly exposed to fire, and we hardly think the suggestion is one which can be carried out.

Lake Superior Tin.—The accounts which are from time to time received from the tin fields of Australia, are in the highest degree gratifying; and indicate that at no distant day the commercial importance of that Island will be greatly enhanced by its production of this metal. In the Kœting field the ore occurs as black, grey, yellow, and ruby tin, and is often coated with oxide of iron; small garnets are frequent and specks of gold are occasionally met with.

Excellent prospects have been obtained over an extensive distric

in the Kœting field, and the development of tin deposits is looked forward to with confidence as likely to add at once very materially to the wealth of the colony. In the first nine months of 1873, ending September 30th, there were imported from Australia into England, 3,520 tons of tin ore, while during the corresponding period of 1872, the amount imported amounted to only 200 tons; a state of affairs which affords the best evidence of the value and genuineness of the newly discovered deposits.

The large importations from Australia, combined with commercial causes, have caused a decline in the prices of the ore, as well as a reduction in the supply from other sources.

While upon this theme, it may not be amiss to state, that recent developments have brought to light the fact, that the reputed discovery of valuable tin deposits on the North shore of Lake Superior, which were extensively circulated by the mining press of the country upon what appeared to be very substantial evidence of genuineness, is another disgraceful attempt at swindling upon an altogether unprecedented scale.

The following letter written by a correspondent of the *London Mining Journal*, will sufficiently explain the condition of things, and renders comment unnecessary.

"SAULT STE. MARIE, JUNE 21st.—*To the Trustees of the Otter Head Tin Pool.*—In November last, I made a cursory examination of the supposed tin lands near Otter Head, on the North shore of Lake Superior, spending only about two hours on the ground, the threatened immediate closing of navigation preventing a longer stay. I took specimens from two veins which I thought contained tin, and a careful assay proved the fact to our satisfaction. Having just returned from making a closer examination of the same lands and veins, I desire to report that I found unmistakable evidences that, by artificial means, tin had been placed in the fissures and veins, probably in liquid form, which afterwards assumed the appearance of artificial stone containing the metal. As proof that such was the case, I found buried near these veins, four barrels of silicate of soda, a box containing clay, and other materials, which I suppose to have been used in carrying on the deceptions practiced upon the gentlemen who made the necessarily hasty examination in November, 1872, in company with Mr. Pennock. I found the original vein; the matrix had been worked out with a pick for some depth, and then filled with an artificial rock containing dressed tin of a high per centage. I must admit that, at the

time of my first visit, I was deceived, and attribute the deception to the very short time given us for examination, which under the circumstances could not be thorough, and now declare it a fraud and swindle, perpetrated, aided and abetted by men whom I could not believe would be guilty of so base a transaction. I regret ever having seen or heard of the property, yet it may prove valuable in other minerals, which I hope may be the case for all interested. WM. HARRIS.

The British Exports of Coal for the nine months ending 30th Sept., by the Board of Trade Returns, amounted to 9,444,464 tons, of the value of £9,924,272, being about 650,000 less in quantity, and £2,700,000 more in value than for the same period of 1872. For the month of September the exports of coal were 1,134,893, of the value of £1,168,441, being 74,000 tons less in quantity than for September, 1872.

Can Electricity be Profitably Employed as a Source of Power?—There was recently on exhibition in one of our industrial expositions a series of pumps, worked by exhaust steam, over which was placed the startling announcement, that, by means of them, water might be raised to a given height in quantity sufficient to drive a water-wheel which would give out more power than the steam-engine itself! The placard was well calculated to attract attention, but then nobody believed the statement printed on it, for the simple reason that no engine, far less the exhaust steam from one, could ever pump up water enough to drive a wheel which would give out half the amount of power of the original motor. The waste in pumping and the loss caused by want of efficiency in the water-wheel would be sure to consume the other half. Now it happens curiously enough that there are in common use two methods for producing dynamic electricity—one being the voltaic battery and the other any form of mechanical power. In regard to the latter, it is evident that the same principle holds true in regard to it that is true when applied to the water-wheel and steam-engine above mentioned. If electricity, which has been produced by the agency of mechanical power, be applied to the driving of an electro-motor, the latter can never be made to give out as much power as has been exerted by the engine employed to produce that electricity. In other words, no one could be found so foolish as to employ a steam-engine to produce electricity for the purpose of operating an electro-motor intended to drive machinery. It would evidently be vastly more economical to drive the

machinery by means of the engine itself, without the intervention of any complicated apparatus.

This proposition is so self-evident that it requires no elaborate demonstration; but from it follows the very obvious conclusion, that, if by means of the steam-engine we can produce electricity more cheaply than we can by the voltaic battery, then it is evident that the battery cannot compete with the engine as a source of power, no matter how perfect may be the electro-motor through which the energy derived from the battery is applied. Hitherto it has been claimed that the only difficulty in the way of applying electricity as a motive power consists in the absence of a properly constructed electro-motor; but if it can be proved that electricity can be produced more cheaply by means of steam than by the consumption of zinc, then it is clear that even a *perfect* motor—that is to say one that utilizes *all* the electrical energy, and converts it into mechanical power—cannot enable the battery to compete with steam.

Here, then, is a crucial test which is easily applied. And we believe that the results already attained do not leave the question in any doubt. In the case of the electro-deposition of metals, as well as the production of the electric light—two instances in which the comparison between the engine and the battery may be made with great accuracy—it has been found that the engine is the most economical. *A fortiori*, it should be far more economical as a source of mechanical power.—*The Technologist.*

Russian Mining Industry.—The following information concerning the mining industry of Russia may be read with some interest. In 1871 the number of mines owned by Russia and producing gold were 979, platinum 6, silver 21, copper 76, iron 1174, zinc 6, cobalt 1, tin 1, coal 327, pyrites 1, chromium 6, rock salt 4, besides 697 naphtha pits. Their yield was, from 17,000,000 tons gold sand, 86,400 pounds of gold; from 168,000 tons of platinum sand, 4,504 pounds of platinum; 35,120 tons of silver ore; 100,365 tons of copper ore; 820,000 tons of iron ore; 42,400 tons of zinc ore; 10½ tons of cobalt ore; 8,000 tons of pyrites; 817,000 tons of coal; (stone coal and lignite); 22,000 tons of naphtha; 7,000 tons of chromic iron ore; and 455,000 tons of rock salt. The smelting works of Russia produced from these ores 29,000 lbs. of silver, 1,740 tons of lead, 4,200 of copper, 8 of tin, 2,700 of spelter, 354,000 of pig iron, 30,000 iron castings, 241,500 wrought iron, 7,000 steel, 350 copper sheets, 500 zinc sheets.

New Apparatus for Testing Oils.—The *Bulletin de la Société d'Encouragement* contains a description of Garnier's apparatus for testing the inflammability of petroleum oils intended for illumination, which is noticed as follows in the *American Chemist*: "It consists of a cylindrical box, having a wick supported in its centre, across the top of which is a curved metal rod terminating in the bottom of the cylinder at both ends. The oil to be tested is poured in to a fixed height, the wick is lighted, the cover is put on—leaving an air space above the liquid—and a thermometer introduced through an opening. As the temperature of the oil rises by conduction of the heat along the rod, the thermometer column ascends. When the flashing point—which in France is 55° C. (131° F.)—is reached, the puff produced by the explosion extinguishes the flame, and the reading of the thermometer gives the point sought.

Franklin Institute.

Proceedings of the Stated Meeting held January 21st, 1874.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at the Stated Meeting held January 14th, 1874, donations had been received for the Library from the following:—

Ordnance Memoranda, No. 15.

Report of the Board of Officers appointed in pursuance of the Act of Congress, approved June 6th, 1872, for the purpose of selecting a breech system for the muskets and carbines of the military service, etc. From the Chief of Ordnance, Washington, D. C.

Pennsylvania Reports of the Inspectors of Mines for 1872. From William A. Rolin, Esq., Philadelphia.

Transactions of the Literary and Historical Society of Quebec, Session of 1872–1873. From the Society.

Columbus, Ohio, its History, Resources and Progress, with numerous illustrations. From Jacob H. Studer, Esq.

Results of an Experimental Inquiry into the Mechanical Properties of Steel. (Duplicate.) By David Kirkaldy. From the Author, London.

A Catechism of High Pressure, or Non-Condensing Steam Engines.

By Stephen Roper, Esq. From the publishers, Claxon, Remsen & Haffelfinger, Philadelphia.

Annales des Ponts et Chausseés, for July, 1873. From the Editor, Paris.

Verhandlungen der K. K. Geologischen Reichsanstalt for April, 1873. From the Society, Vienna.

Jahrbuch derselben for April, May and June, 1873. From the same.

Die Cephalopoden-fauna der Gosau Schichten in den Nordöstlichen Alpen. From the same.

Proceedings and Transactions of the Nova Scotian Institute of Natural Sciences of Halifax, 1873. From the Institute.

Minutes and Proceedings of the Institution of Civil Engineers, Session 1872–73, Parts 1 and 2. From the Society, London.

Journal of the Royal Geographical Society, 1872. From the Society, London.

Monthly Notices of the Royal Astronomical Society, for November, 1873. From the Society, London.

Message of his Excellency John F. Hartranft to the General Assembly of Pennsylvania, January 7, 1874. From the Author, Harrisburg, Pa.,

The Actuary likewise presented the minutes of the several standing committees.

The President next presented the following:—

REPORT OF THE BOARD OF MANAGERS FOR THE YEAR 1873.

Your Board report that during the year 1873 there have been added to the list of members 91 new names; resignations from 31 having been accepted, the increase of membership has been 60.

An effort has been made during the year to perfect a list of the life members, but it has not yet been accomplished.

Circulars were issued representing the desirability of increasing our list of members, and some persons, not residents of the city, have expressed their willingness to become contributing members.

The Treasurer's Report shows a balance on hand January 1st, 1873, of	$ 1,350 19
Receipts during the year 1873,	10,393 57
Total,	$11,743 76
Expenditures during the year,	10,047 24
Leaving a balance on hand of	$ 1,696 52

A large portion of the receipts and expenditures are incident to the publication of the Journal. The most rigid economy has always been requisite to make this publication meet its own expenses. The Committee on Publications report that the financial condition of the Journal is better than it has been for

many years previous, there being a cash balance on hand at the end of the year, included in the general cash balance, of $681·21; but in this connection it must be remembered that no portion of the Secretary's salary has been charged to the Journal, so that the pecuniary success of the Institute's publication is largely due to the fact that the Secretary of the Institute acts as Editor.

Additions to the Library during the year have been as follows:

Bound volumes, ...	168
Unbound volumes, including Journals, pamphlets, proceedings of Societies, etc., ...	222
Total additions, ...	390

The Drawing School, which was enlarged during the year 1872, was this year placed under the charge of Professor Alfred C. Wernicke, and your Board are pleased to report very favorably of his management of the school.

No. of pupils (1st session), ...	92
" " (2d session, thus far), ...	64
Total, ...	156

The importance of this department becomes more evident each year. During the early history of the Institute, the only means which artisans had of acquiring instruction in drawing, chemistry and natural philosophy was through the instruction given in these halls. Now, the introduction of night schools as an adjunct to the public school system, has opened new means to this end, so far as regards chemistry and physics; but the real value and need of instruction in drawing has not seemingly effected a like result, and the school of the Institute is of the greatest importance.

An effort has been made to secure the services of volunteer lecturers for the course of 1873, with encouraging results; and your Board have to thank Prof. E. D. Cope and Dr. Henry Leffmann for their services in this direction; while in the list of volunteers for the last part of the course will be seen the names of such distinguished men as Profs. E. D. Cope, J. P. Lesley, G. F. Barker and Mr. S. Lloyd Wiegand.

The Optical Section has also arranged to hold two special meetings on evenings usually devoted to lectures, for the purposes of displaying illustrations by the magic lantern and oxy-hydrogen microscope.

Two awards of the Scott Legacy Premium have been made this year—one April 9th, to William Wharton, Jr., for his invention of a "Safety Switch for Railroads," and one June 2d, to John H. Irwin, for his invention of a "Tubular Lantern."

The Optical and Meteorological Sections have held regular meetings, but no new sections have been organized.

Your Board desire to call attention to the fact that, as the first steps were taken by this Institute that led to the selection of Philadelphia as the place for holding the great Exposition in the year of the Centennial of American Independence in 1876, it is of the utmost importance that not only each member of the Institute should individually exert himself to aid the Commissioners in their great work, but that the Franklin Institute itself, as the leading Soci-

ety of its kind in the land, should exert itself in the same direction. To this end there is need, urgent need, of a great increase in the number of our members.

By order of the Board,

COLEMAN SELLERS, *President.*

On motion of Mr. Chattard, the Report was accepted and ordered to be placed upon the minutes.

Upon the call for the Reports of Special Committees, Mr. Chas. S. Close, from the Committee on Conflagrations asked for its discharge, stating that the work of the Committee was practically finished by its elaborate report on the petroleum oils made at the meeting in April last. The Committee was thereupon, on motion, discharged, with the thanks of the Institute.

On behalf of the Committee on Dynamical Terms, the Chairman, Mr. J. W. Nystrom presented the following:

REPORT.

The Committee on Dynamical Terms, appointed by the Franklin Institute at the September meeting last, has examined the subject entrusted to it, and finds that great indistinctness exists among scientific bodies and writers, here and elsewhere, in the use of scientific terms in dynamics.

Each dynamical quantity bears a variety of terms, differently defined, while it would appear that each quantity needs only one term, with one definition.

The following list of dynamical terms is collected from the works of RANKINE, MOSELEY and BARTLETT, which terms appear to be not clearly defined, and to be employed by these writers, respectively, in order to convey different ideas:

Terms used in Dynamics.

Efficiency of force.	Total quantity of work.
Force of motion.	Actual work.
Force of action.	Total amount of work.
Working force.	*Vis-viva*, or living force.
Quantity of moving force.	Energy.
Quantity of motion.	Actual energy.
Mode of motion.	Potential energy.
Mode of force.	Energy of motion.
Moment of activity.	Energy of force.
Mechanical power.	Mechanical potential energy.
Mechanical effect.	Quantity of energy.
Quantity of action.	Intrinsic energy.
Efficiency.	Total actual energy.
Rate of work.	Work of energy.
Dynamic effect.	Stored energy.
Quantity of work.	

Many more terms may be quoted as unnecessary, but this list may be suffi-

cient to draw attention to the importance of establishing precision to the meaning of dynamical terms.

The Franklin Institute, being a body largely composed of persons engaged in the mechanic arts, as also in instructing students in mechanics, experiences great difficulty in carrying out its objects with efficiency from the indistinctness referred to. Hence it is believed,—

That it is highly desirable to determine the meaning of such terms, giving them definitions which will be generally acceptable throughout the scientific world, and to eliminate all which may be deemed unnecessary;

That such a work can be best accomplished by a national body of authority; and

That the Smithsonian Institution being such a body, this Committee recommends that the Franklin Institute request it to consider the subject and take such action as it may deem proper to bring about this desirable object.

FAIRMAN ROGERS,
J. VAUGHAN MERRICK,
LEONHARD G. FRANCK,
JOHN H. TOWNE,
JOHN W. NYSTROM.

It was thereupon moved that the report be received and the recommendation therein contained adopted. On call of Mr. W. P. Tatham, the question was divided; and, on being put to vote, the motion to receive the Report was passed, and that to adopt its recommendation was lost. The request of the committee to be relieved from further consideration of the subject was agreed to.

On behalf of the Committee on the Celebration of the 50th Anniversary of the Institute, the Chairman, Mr. Coleman Sellers, reported that no large hall being available for the evening of the anniversary, the Committee had decided to engage the Musical Fund Hall for the occasion, and that a number of prominent members of the Institute had promised to deliver addresses on the evening in question. On motion, the report of the Committee was adopted, and it was ordered that when this meeting adjourned, it would adjourn to meet at the Musical Fund Hall, on Friday, February 6th, at the usual hour.

The Committee to draft a minute expressive of the sense of the Institute with regard to the death of Prof. Agassiz, presented through its Chairman, Mr. Hector Orr, a report, which after several verbal amendments was finally adopted, as follows:—

Whereas, The Franklin Institute has learned with deep regret of the death of Professor Louis John Rudolph Agassiz, therefore

Resolved, That in this event Zoological Science and the cause of Truth in general, have suffered a severe bereavement.

As the undisputed successor of Cuvier, he has stood for years the foremost naturalist of the age. In choosing our hemisphere as the field of his latest researches, he did the world a great service while he honored us, and in fixing his home in America, spending his life here and electing us the custodians of his grave, he has given our people a still nobler distinction.

The modesty of his announcements is as singular as the faithfulness of his investigations, and these united present him as a true apostle of the highest grade.

With the inevitable sorrow due to his departure a gratifying recollection mingles, inviting thanks to our brothers of Massachusetts, who made him welcome, in the name of the nation, at their own expense. Long as they shall lead the van in such emulation, Philadelphians will be prompt to acknowledge and appreciate the same. "The Athenians know what is right, but the Spartans practice it!"

Resolved, further, that a copy of this minute be sent to the family of Professor Agassiz, and also to the Governor of the State of Massachusetts.

HECTOR ORR,
J. G. HUNT, M. D.,
B. H. MOORE.

The tellers of the election for Officers of the Institute reported the following named gentlemen elected:

President.—Coleman Sellers.
Vice-President.—Robert E. Rogers.
Treasurer.—Frederick Fraley.
Secretary.—William H. Wahl.

Managers (*to serve three years*).—E. J. Houston, J. E. Mitchell, Charles Bullock, William Helm, William B. Le Van, Samuel Sartain, Enoch Lewis, F. B. Miles.

Managers (*for one year*).—George F. Barker, Theodore D. Rand.

Auditor.—William Biddle.

The President thereupon declared the gentlemen above named to be the officers elect of the Institute, and gave a brief address expressing his appreciation of the compliment of a reëlection.

The tellers of the special election to determine whether or not the Library and Reading Room shall be opened on Sundays, reported the number of votes for the proposition to be 87; against, 42. The President thereupon declared it to be the will of the Institute that the library and reading room should be opened on that day.

Mr. E. F. Loiseau, of Mauch Chunk, was next introduced, and read a paper on the subject of artificial fuel, which will be found published in the Journal of the Institute for February, 1874.

Mr. T. C. Clarke, Esq., of Philadelphia, then gave a description of the iron bridge now in course of erection by the Phœnixville

Bridge Co., across the Schuylkill at Girard Avenue. The paper was illustrated by aid of the stereopticon, and specimens of the decorative work; and will be found published in the Journal for March, 1874.

Under the head of new business, Prof. J. P. Lesley announced the fact that a bill was now pending before Congress to cut down the appropriation for the publication of the Nautical Almanac from $20,000 to $10,000, and urged that an emphatic protest should proceed from the Franklin Institute against any such proposition to cripple so valuable and useful an institution. He offered, thereupon, the following preamble and resolution, which were unanimously adopted.

WHEREAS, The Franklin Institute learns with deep regret of the intention of the Government at Washington to curtail the amount of the appropriation for the U. S. Nautical Almanac;

WHEREAS, In the opinion of this Institute, the Nautical Almanac is one of the most practically useful of those efforts of American science which stand before the world unsurpassed by any other nation;

WHEREAS, In the economy of the management of this great national work, as well as in the accuracy of the details which it furnishes, the American Nautical Almanac is an object of necessity for commerce, and pride to our citizens, and a model to other countries;

Resolved, That the Franklin Institute respectfully petition Congress rather to increase than to diminish the appropriation for an object so catholic, so necessary, and so creditable to the country.

Mr. J. W. Nystrom then gave notice of his intention to present at the next meeting of the Institute the following, as an amendment to the By-Laws:

Resolved, That the Institute shall hold a social meeting on the second Friday of each month, from 8 to 10 o'clock P. M., except in the months of July and August.

That the members shall be at liberty to converse freely in the hall of the Institute during the social meeting; and

That no lecture or other meeting shall be held at the Institute during the social meeting.

The meeting then adjourned.

WILLIAM H. WAHL, *Secretary.*

Civil and Mechanical Engineering.

THE GUNPOWDER PILE-DRIVER.

By F. C. Prindle, C. E. U. S. N.

The novel and efficient use of gunpowder in the mechanic arts, and its successful application to pile-driving, has now become pretty generally known in this country, but results and facts developed by its use are still eagerly sought by the engineering world.

In view of this, it has been suggested to the writer that the subject was of sufficient interest and importance to justify the presentation of some recent improvements in the construction of the apparatus, at this time, and to which he has consented to respond.

In order to facilitate a more intelligent understanding of the general features and advantages of this particular design, it will be necessary to refer to the peculiar requirements of a machine operated by this novel process, which does so much credit to its inventor, Mr. Thos. Shaw, of this city, and briefly describe and discuss the principal features of the construction of the several forms of machines heretofore used.

The enormous power developed by the explosion of confined gunpowder, as used in this process, calls in the first place for a strong and rigid framing to resist the sudden and severe strains imposed upon the guides when at work; and the close-fitting plunger entering the gun at every stroke requires a good degree of mathematical precision in the fitting of the guides upon which they travel; while the application of a friction brake to arrest and retain the heavy ram in position, at any point of its travel, involves the use of a special appliance for this purpose, and the consideration of other strains incident to its use, and to which the framing itself is subjected when not in operation.

Manifestly, then, the ordinary pile-driver frame is not adapted to this new order of things, and several attempts have been made, since this discovery, to produce a suitable framing that would satisfactorily fulfil all the requisite conditions without being unwieldy, and at a moderate cost. The principles involved in the process, and the efficiency of its action, were fully demonstrated at the outset, and to successfully harness this mighty engine, and place it in practical operation under safe and easy control, in order to utilize its power—

a question of mechanical construction alone—has been the problem under solution ever since.

The different arrangements and modifications of form devised to attain this end, and placed in operation, having come under the observation of the writer from time to time—two of the earliest forms of machines, though now abandoned, having successfully driven over 3,000 piles on works under his charge—has suggested the ideas embodied in the plan herein illustrated and soon to be described.

The first form of machine put to practical test, consisted of a wooden frame almost identical with the ordinary pile-driver, but having the ways or guides of cast iron made in short lengths with U shaped sections and secured to the inner opposing faces of the uprights.

The ram was caught and held in position at the highest point of its ascent by means of a pawl engaging with the teeth of a rack secured to one of the uprights, the pawl being ingeniously constructed so as to release at will by pulling a cord from below. This part of the apparatus, however, was soon superseded by a continuous friction brake, which was applied from one side of the machine, with its arm brackets bolted to one upright, and the brake bar of angle iron pressing the ram in a corresponding V groove against the opposite upright.

While this machine fulfilled the desired conditions as to weight and portability, it did not possess the more essential of strength and durability, and but two or three of this kind were built.

The action of the brake forced the uprights and guides apart, throwing the plunger out of line with the gun, and distorting the frame at every blow.

The next form was constructed largely of cast iron.

The uprights were cast in 5 feet sections, both in one piece, and connected together at each end on the back, with deep crescent-shaped cross bars or ribs, and the sections were bolted together at the ends. The guides were V shaped, sunk on the inner faces of uprights, and tool dressed, as were also the ends of the sections, so that their alignment was perfect.

The brake bar was located and applied as before, and the strain of its action was transmitted through the curved cross-rib connections, from one upright to the other, the tendency of which was to separate the guides.

This was a decided improvement in many respects, especially as regards rigidity; but the machine was excessively heavy and unwieldy, owing to the great amount of cast iron used in its construction.

The shocks and sudden strains to which it was subjected, however, soon demonstrated its want of durability, especially in frosty weather, when breakages were frequent, and it was finally, after many renewals and repairs, reduced to the scrap heap, though not until after it had successfully driven some 2,000 piles, over 1,000 of which were upon the work under the writer's supervision.

It is this machine and its operation which were illustrated and described in the June No. of the JOURNAL for 1872.

The next form of construction indicated a return to the combination plan of wood and iron framing. Cast iron guides, of V section, and tool dressed, were secured to the inner faces of the wood uprights as in the first plan, but the braces connecting the uprights together were made of cast iron, as last described, and bolted to them.

The friction brake, with the usual angle iron brake bar, was applied in the centre of machine from the rear, an arm of the ram projecting sufficiently to receive the brake. A central upright of cast iron in sections, was secured to the cast iron braces, and to this the outer ends of brake arms were pivoted.

The use of this machine soon developed a serious defect in the operation of its friction brake, the pressure upon the V guides from one side (illustrated by the relative direction of this line) acting like a wedge, easily spread them and forced the ram out of line. This necessitated the addition of a flat surface on the opposite side of the guides, at a right angle with the direction of pressure, for the flat part of the ram arm to press against, instead of the oblique surface of the V.

This V form of guides was next abandoned entirely, and a half dove-tail form adopted, and the cast iron guide plates were replaced by those of steel with the groove tool dressed.

This change was quite successful, and considerable work has been performed by machines of this construction, over 2,000 piles having been driven by one machine on works under the writer's charge. The combination of wood and iron, however, was unsatisfactory, the cast iron was unreliable, the brake apparatus directly in the way, and the weight of machine too great.

The experience gained by these repeated failures seemed to point to the necessity of returning to a metal guide frame entirely, and the next form produced was made of McHaffie steel.

The uprights were of T section, gradually diminishing in size from base to top, cast separately in about 5 feet sections, and ends bolted

together with fish plates. The guides were of half dove-tail section, projecting from flange face centrally and tool dressed, as also were the ends of the section, to secure the necessary alignment.

A double brake apparatus was attached, one on each side, and applied from the rear. The brake arms and brackets were of steel, and bolted to web and rear flange of uprights, and the brake bars were of the usual angle iron. The uprights and guides were secured the proper distance apart, by stout iron rods fitted with jam nuts, and passing through the side bars of framing, which were of wood, and bolted to flange of uprights and to the ladder; some dependence also being placed upon the dove-tail guides to assist and support each other through the gun and ram.

This plan succeeded well, and several fine machines, some as large as 60 feet high, and fitted with a steel gun of 8½ inches bore, and a 3000 lb. ram, have been put afloat and in service in different sections of the country, with good results as to efficiency and durability.

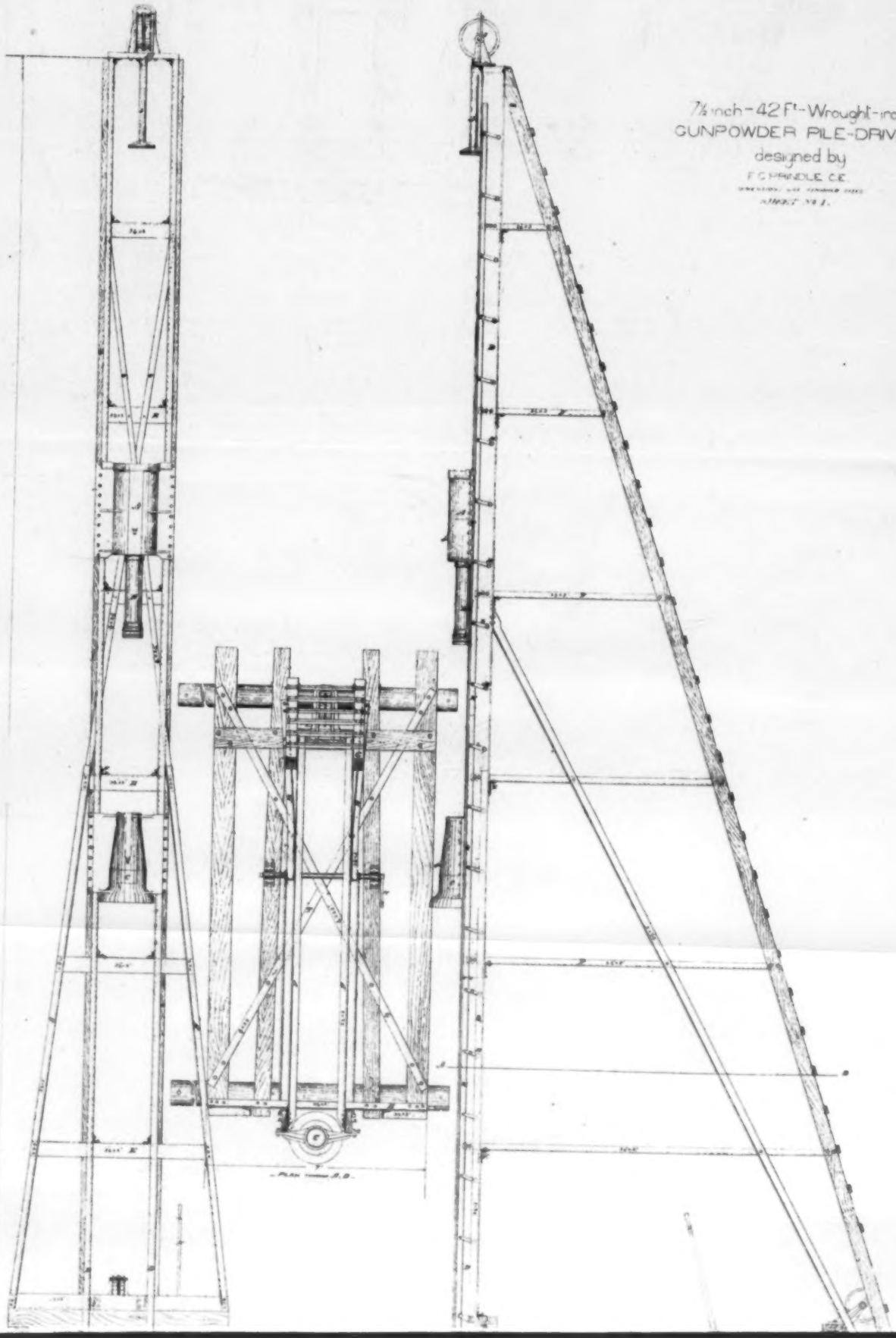
The cost of the steel itself, and the somewhat difficult machine work required to fit it for use, the writer is informed, renders it still too expensive, and it is also too heavy and cumbersome.

The design here illustrated from the working drawings, for a wrought iron frame, and which has been successfully tested, is next in order and will now be considered.

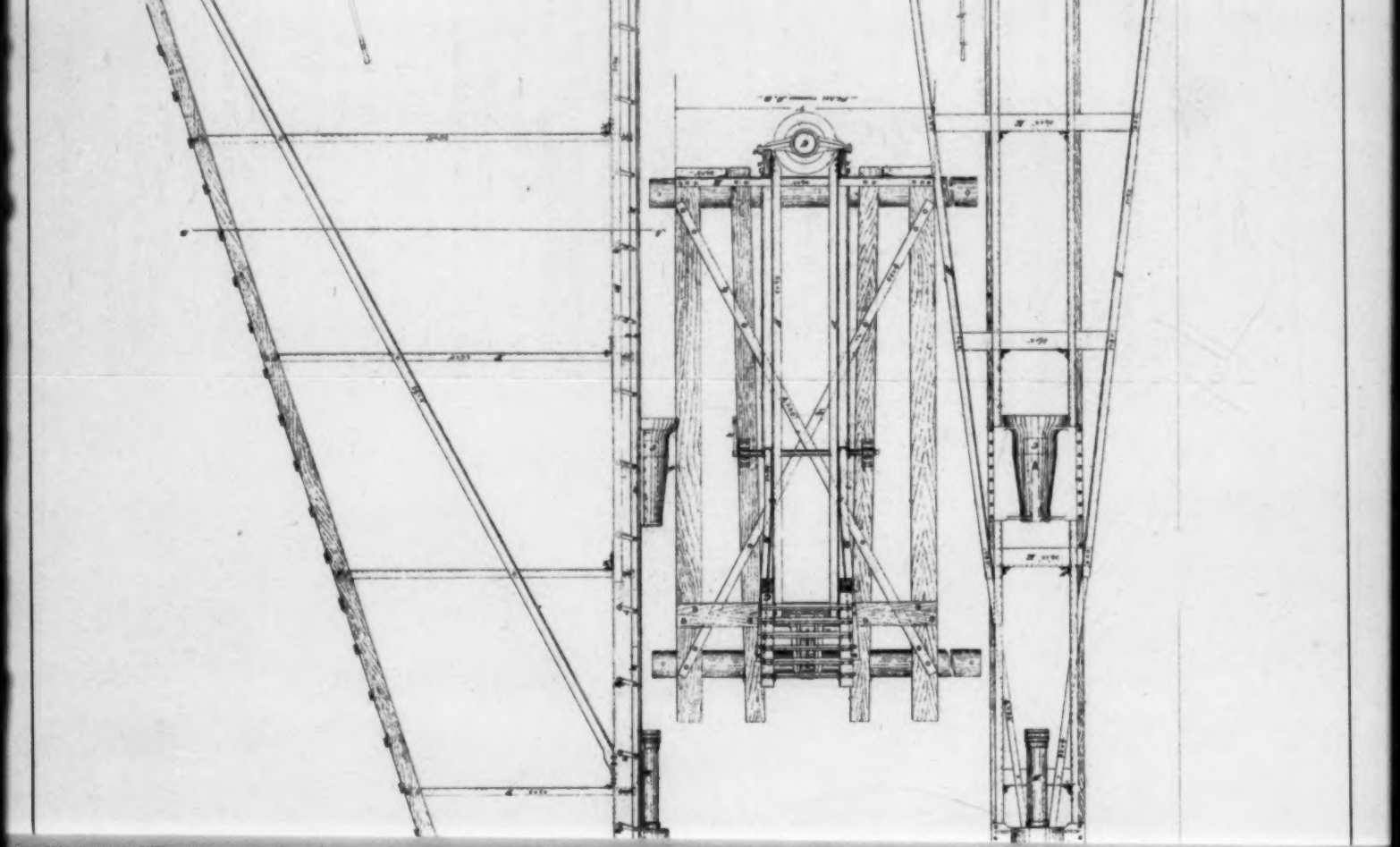
Referring to the plates, A is the ram, of cast iron, provided with its plunger B, upon the lower end of which is screwed a steel ring or band and turned to neatly fit the bore of the gun below—the whole weighing 2170 lbs. C is the gun, of steel manufactured by the McHaffie process, and weighing 1300 lbs. It has a bore 7½ inches diameter and 24 inches deep, pointing upward, with its mouth slightly bell-shaped to receive the ram plunger at each stroke. Its walls are 3¼ inches thick at base, and the lower end is recessed to receive the head of piles. D D are the uprights of the frame, each consisting of a single piece of light nine inch channel bar of rolled iron, 42 feet long and weighing 50 lbs. per yard, with their flanges turned outwards, and the front flanges forming the guides or ways, up and down which both ram and gun move.

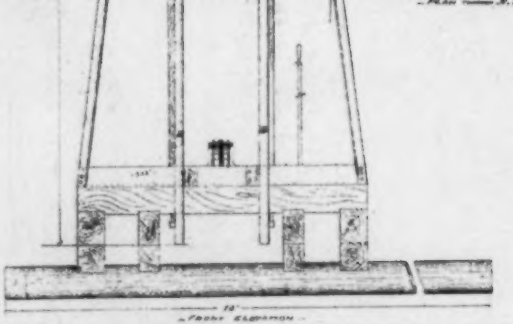
The uprights are firmly secured together the proper distance apart, by means of angle iron cross bars, E, riveted to the rear flanges, and spaced six feet apart. The side bars, F, of the framing are of angle iron also, one end of each of which is bolted through its vertical flange to the inside of the web of the uprights, and to the upper

Journ. Franklin Inst. 4th. S. XXVI

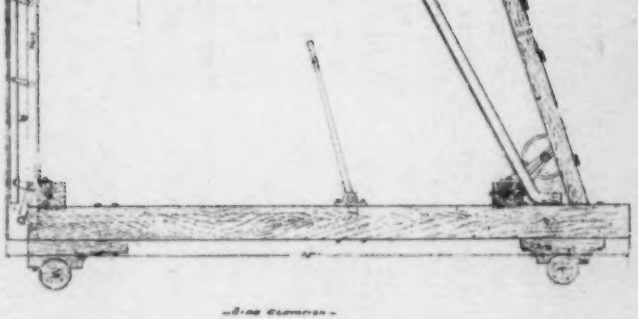


7½ inch - 42 Ft - Wrought-iron
GUNPOWDER PILE-DRIVER
designed by
F. C. HANDLE, C.E.
SHEET No 1.



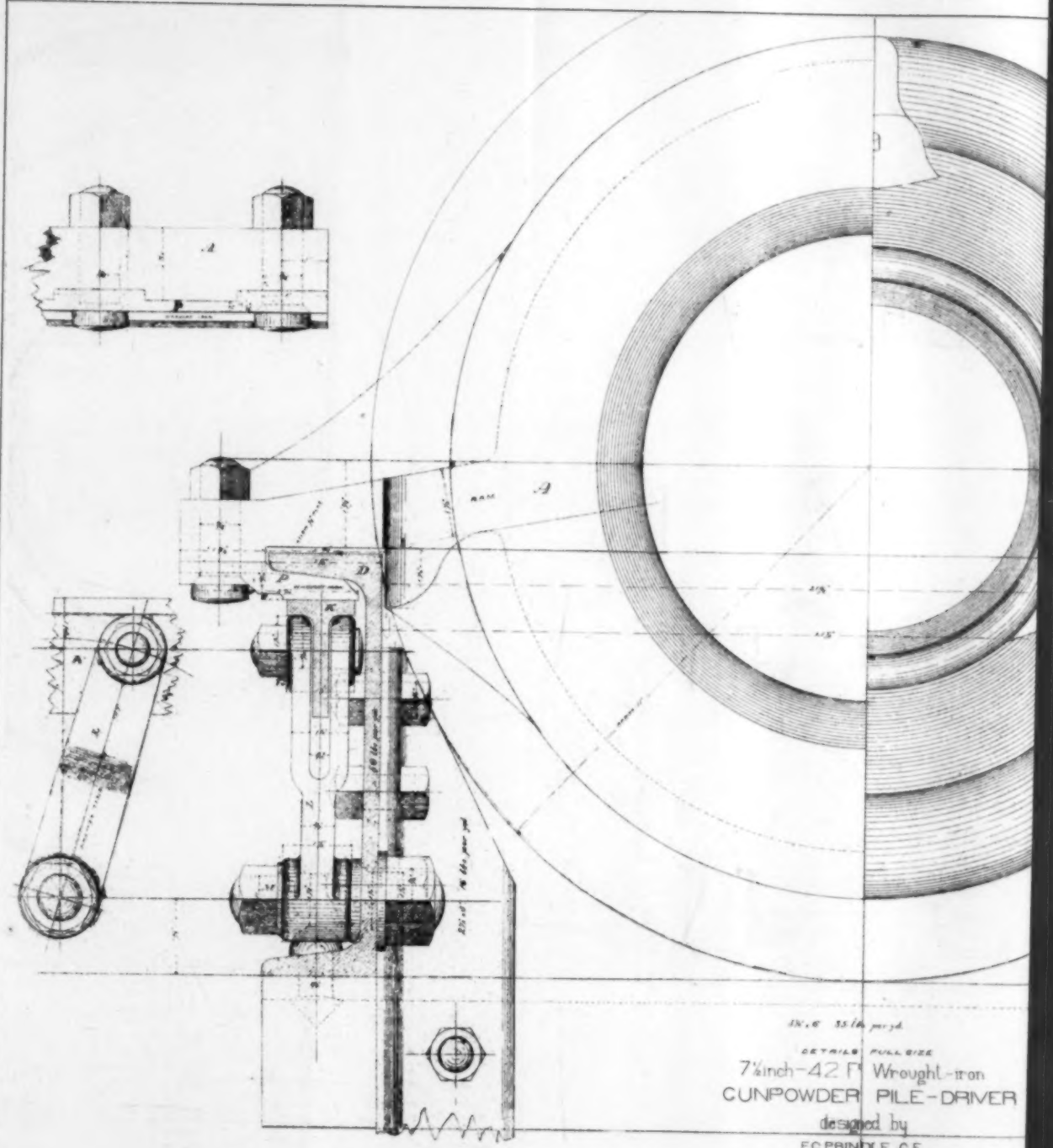


Front Elevation



Side Elevation

Photo Litho. by A. Hoen & Co., 340 & 342 Pl. St. Pl. Md.



DETAILS FULL SIZE

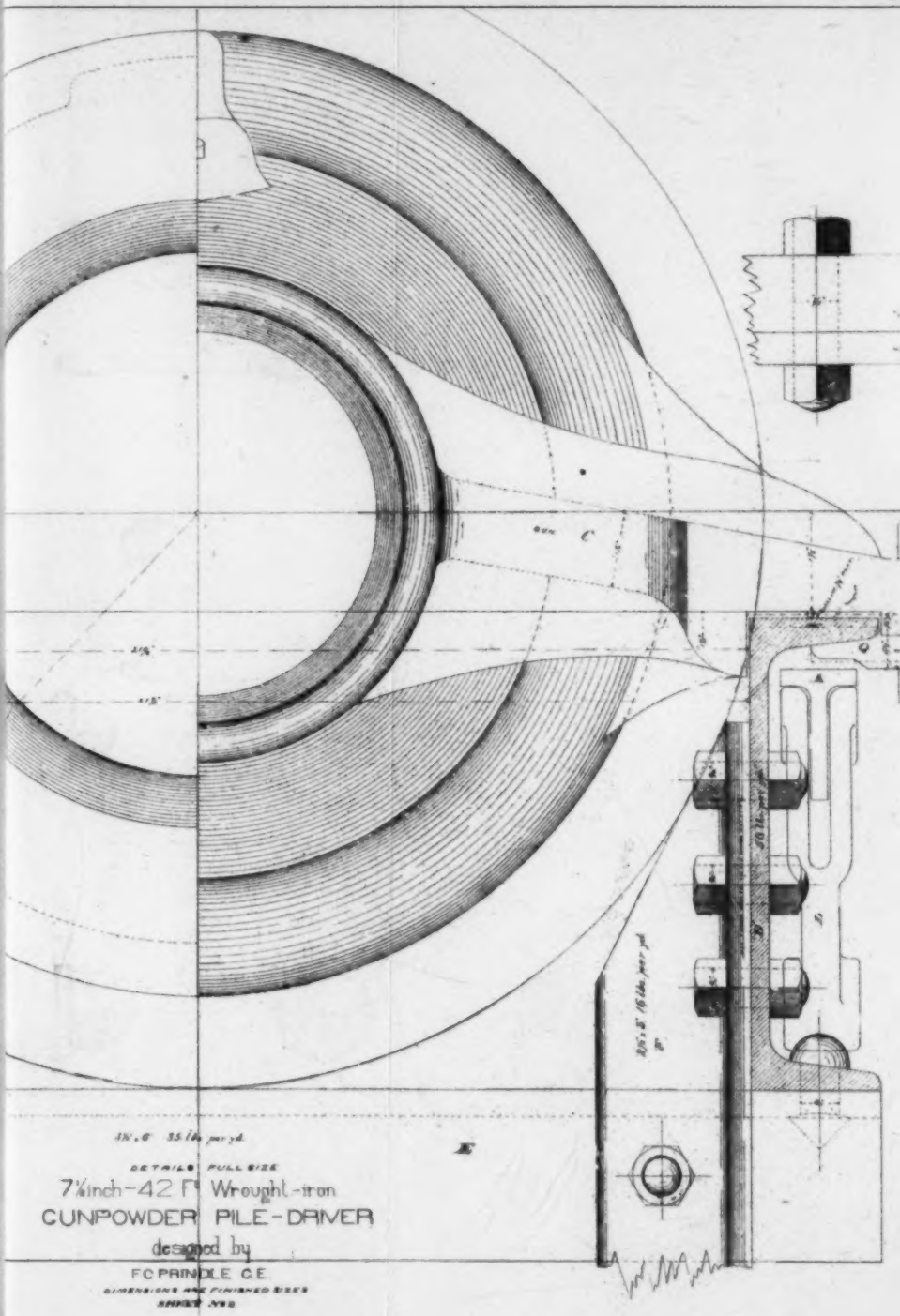
7¼inch-42 ft Wrought-iron

GUNPOWDER PILE-DRIVER

designed by

F.C. PRINDLE C.E.

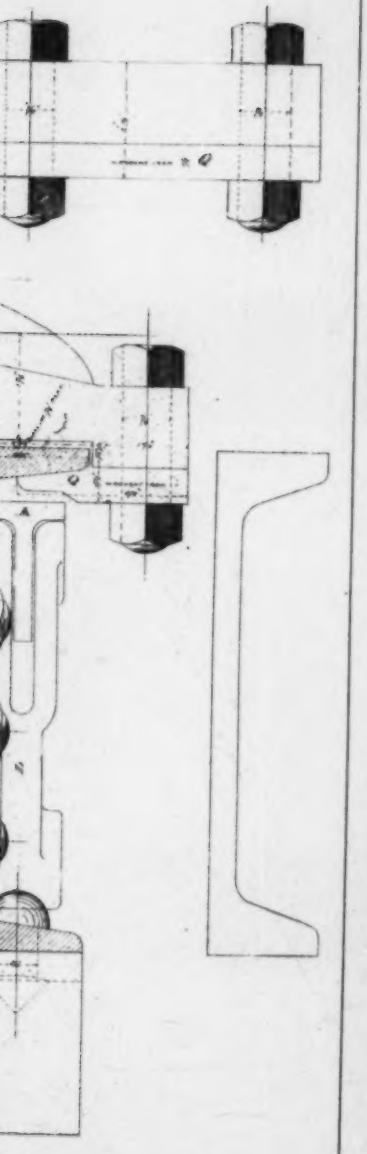
DIMENSIONS ARE FINISHED SIZES



DETAILS FULL SIZE

7¼inch-42 ft Wrought-iron
GUNPOWDER PILE-DRIVER
designed by
F.C. PRINDLE. C.E.

DIMENSIONS ARE FINISHED SIZES



flange of the cross bar through its horizontal flange, thus forming a sort of gusset stay or brace to stiffen the guides transversely, and the other end is bolted to the ladder, G, which is made of wood.

The cross-head, H, at the top of the frame, made also of light nine-inch channel iron, and secured to the uprights by angle iron brackets riveted on, carries the runner sheaves, I, and cushioning piston, J, bolted to its upper and under sides respectively. This fixed piston fits into a corresponding bore of the ram to form an air cushion, and prevent the escape of the ram from the guides when the height of its rebound is limited, as during the first blow with long piles.

The friction brake attachment, by which the ram is held in position at any point, is located (one on each side of the machine) between the flanges of the uprights, on the outer side, and consists of a brake-bar, K, made of very light T-iron, and brake-arms, L, made of McHaffie steel, spaced two feet apart and pivoted to the studs, M, in the web of uprights, and is operated by lever, N, through the link, O. By this arrangement of the brake it is well protected from injury while at work, the connections are short and direct, and the strains of its action are self-contained in a single part of the machine, and not transmitted from one part through others to another part, with a powerful tendency to separate them at every stroke as heretofore.

The friction surfaces of the bar and guide are likewise effectually protected from any fouling action from the gun, which has been a source of much trouble in other machines, especially in damp weather when the brake would not hold well. The adoption of the light T iron brake-bar, instead of the angle iron heretofore used, affords the requisite strength with less weight, admits of a simpler and shorter pin connection with the ends of the brake arms, and thereby permits the use of as small as nine inch channel iron for uprights; and at the same time it allows sufficient room between the flanges for the use of a six inch brake-arm, while the small flat friction surface has proved to be as effective as the more extended V of the angle iron.

The axes of the gun and ram project two inches from the face of the guides, in order to give sufficient clearance to the cross-bars when driving crooked piles, but this overhang has not proved detrimental to the action or efficiency of the machine in any respect.

To facilitate the tool dressing and accurate fitting of the jaws of the gun and ram to this particular sectional form of guides, wrought iron plates, P and Q, are bolted to their wings, or arms, to form the inside lips of the jaws, as shown.

The plates, P, of the ram, against which the brake bar bears, are made a little thicker than those of the gun, so that the brake can be applied to the ram only, and they are also notched into the arm a little to resist the shearing strains due to the instantaneous change of motion while in operation, it having been found difficult heretofore to securely bolt anything of any magnitude to the ram. The sills of the framing are of wood and rest upon the long rollers ordinarily used on land machines to facilitate its movement. The diagonal angle and bar iron braces, R, S and T, are merely to give additional stiffness to the framing.

The principle of its action, and manner of operation, do not differ from the original form of construction.

The only advantage or improvement claimed is in the overcoming many of the mechanical difficulties which have been in the way of producing a much lighter and cheaper machine, consistent with the requisite strength, efficiency and durability.

Ordinary rolled iron has, therefore, been largely used in its construction, it possessing all the necessary qualities afforded by McHaffie steel for this purpose at less than half its cost per pound, and with somewhat less weight. Moreover the uprights can be made in a continuous piece, without any joints or bolts incident to the use of cast iron or steel in sections, and, unlike them also, the guides require no machine fitting or tool dressing, while its superiority over cast iron in every essential respect is sufficiently obvious without further comment.

By this plan a saving of about 25 per cent. in cost of construction is effected, as well as a reduction in weight, over the best machines hitherto made, while its operation has been most satisfactorily tested.

It will be observed that the jaws of the ram and gun literally grasp this form of guides, forming a bearing on each of their four faces, so that the uprights support each other; all side thrusts or strains in either direction being thus communicated to them both and borne in common.

By the use of a preferred form of channel iron for the uprights (shown at X, on sheet 2, but which was not so readily obtainable at the time) having shorter and thicker flanges for guides, it is presumed that the necessary groove to fit the guides can be planed in the jaws out of the solid, and perhaps cored with sufficient accuracy to obviate the necessity of fitting any plates, or even of any tool dressing, which would still further simplify and reduce the cost of construction.

To facilitate its being taken apart for transportation, the side bars are only bolted in place, and by their removal the frame is readily taken down.

The following data has been tabulated from records of work done by this process in the writer's experience at League Island :—

No. of record.	CLASS OF WORK.	DESCRIPTION OF MACHINE.	No. of Piles Driven.	Diameter of Piles. Inches.						Distance Driven. Feet.			No. of Blows per Pile.			Weight of Powder per Pile. Pounds.			Weight of ram. Pounds.	Bore of Gun. Inches.
				Top.			Bottom.													
				Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.		
1	Landing wharf.	Cast iron frame.	811	19	10·5	13·1	13	6	8·7	22·5	14	19·4	19	3	5·2	1·3	¼	½	1300	6¼*
2	Foundat'ns for store-house, etc.	Wood and iron combined.	966	15	10	12	11	6·5	8	30	21	24			20			2	1200	5¾†
3	Foundat'ns for iron plating shop.	Same machine.	457	19	9	12·2	14	7·5	8·7	36	20	29·2	85	11	30·4	9¼	1¼	3¾	1700	6¾‡
4	"	Same machine with lighter ram	63	16	10	12·7	12	7·5	9	31	25	29·5	122	39	59·6	15	4	6½	1200	5¾‡
5	"	Wrought iron frame.	172	17·5	9	11·4	12	7	8·3	32·5	26	29·2	30	6	12·7	4⅞	1	3·2	2170	7½‡

* Machine on scow and operated afloat. The first machine employed upon actual work. Piles of heavy yellow pine, and driven through mud, containing clay, to compact gravel.

† Machine operated on land. Piles of hemlock and firmly driven, without pointing, through stiff clayey material mixed with sand, to hard gravel and boulders. Number of blows and weight of powder per pile, approximate.

‡ Machine operated on land and piles of hemlock. Materials, same as No. 2, and in addition overlaid with from 4 to 9 feet of tolerably dry filling, consisting of mud clay, sand and gravel. The wrought iron machine completed this work.

This wrought iron machine was only recently finished, and put in service on the work in hand just before its completion, and the piles driven were placed in clusters of 13 each, spaced 21 feet apart instead of continuous rows.

By carefully comparing data of Nos. 3, 4 and 5 with each other, a great difference will be observed in the number of blows and quantity of powder used per pile, in the employment of differently proportioned machines upon the same work, the ram and plunger of No. 4 being altogether too light and small for its work. A still heavier ram than Nos. 3 or 5, with a proportionate increase of calibre of gun, would doubtless perform the same work with less number of blows and less expenditure of powder; or, in other words, with greater rapidity and economy. Hence the necessity of adapting these ma-

chines in point of capacity to the work upon which they are employed, in order to attain the best results.

It is to be regretted that no reliable data as to actual cost of operation has been obtained.

The work mentioned has been done by contract, and the limited supply of piles to the machines did not permit their constant use without interruption scarcely for a day at a time, the force employed to operate them having been too small to also keep them supplied with piles at the same time. Under favorable circumstances, however, as many as 81 piles have been driven in 9½ hours, and 12 in a single hour. The actual time required to do the work of driving alone usually varied from three-fourths to one and a half minutes.

The character of the work done, in which the chief interest was felt and to which particular attention was directed, has been very satisfactory and far superior in every respect to that done by impact by the ordinary process.

For the work of Nos. 3 and 4, the machine was too short to receive piles of sufficient length to reach the hard bottom without resorting to punching.

By this means, however, and to which this process is admirably adapted, much shorter piles were used, and a saving of material effected, as the pile heads had to be cut off at half tide level.

January 12th, 1874.

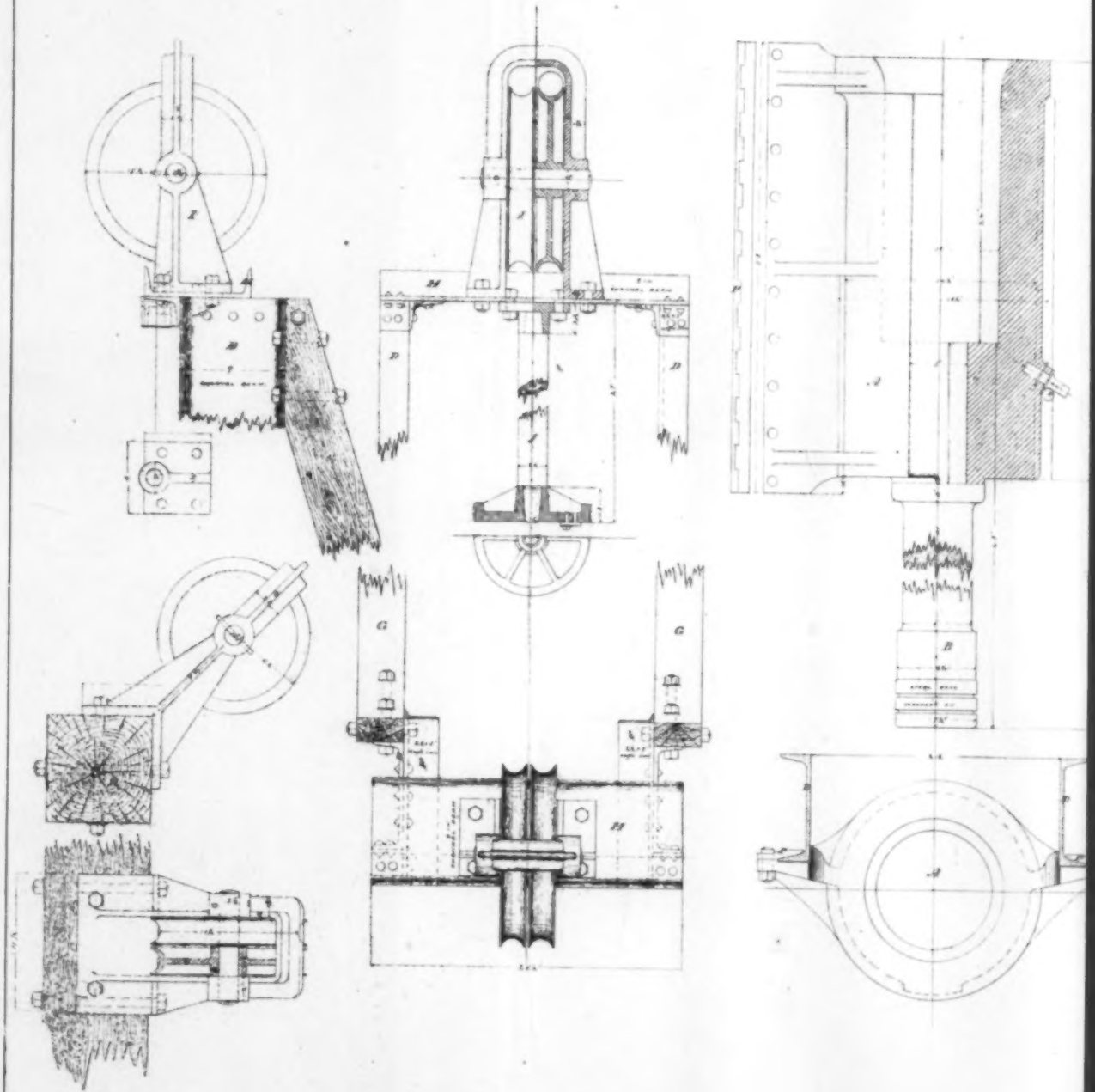
DETROIT RIVER TUNNEL.*

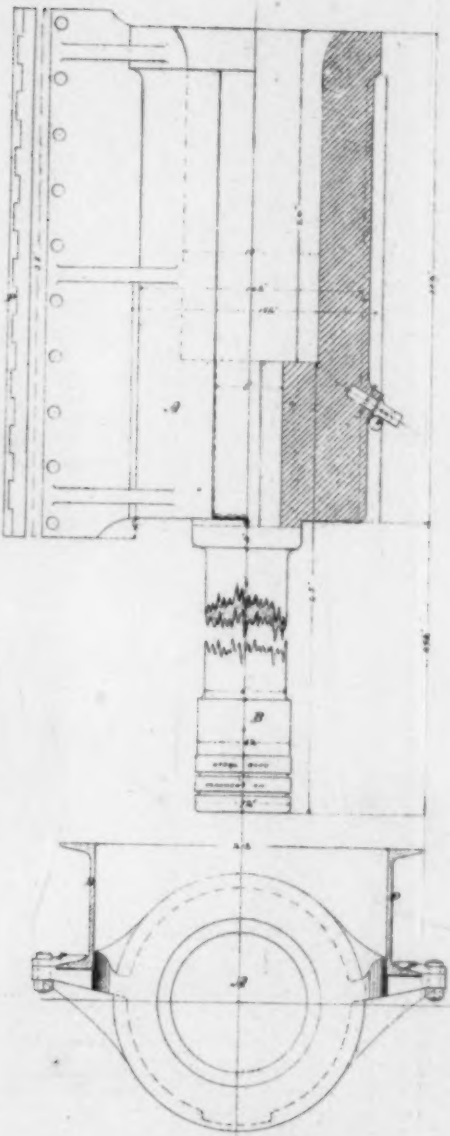
By E. S. Chesbrough, C. E.

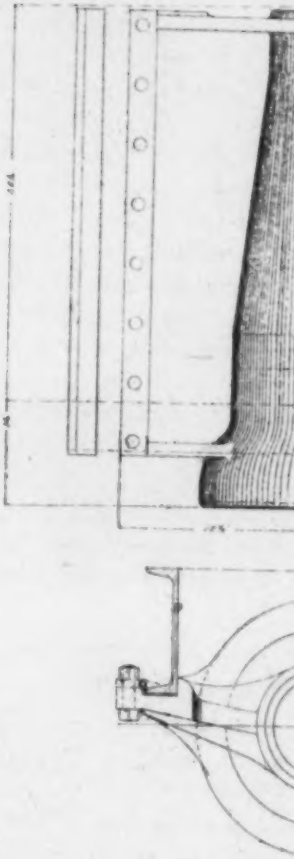
A Paper read at the Fifth Annual Convention, in Louisville, Ky., May 21st and 22d, 1873.

At the date of the former paper† on this subject, read at the last Convention, the preliminary work on the Detroit River Tunnel was in a very encouraging state. The Detroit shaft had been sunk, and a drainage tunnel extended from it for about 600 feet toward the Canada end. The Windsor shore shaft had been sunk to below the bottom of the drainage tunnel, which had progressed about 100 feet toward the Detroit end. With the exception of finding harder ground, and consequently making slower progress than had been originally expected, the prospect of a successful completion of the work was

* LX Transactions of the American Society of Civil Engineers, Nov., 1873.
† XLII Transactions of the American Society of Civil Engineers.







DETAILS

7½ inch - 42 Ft Wro

GUNPOWDER PIL

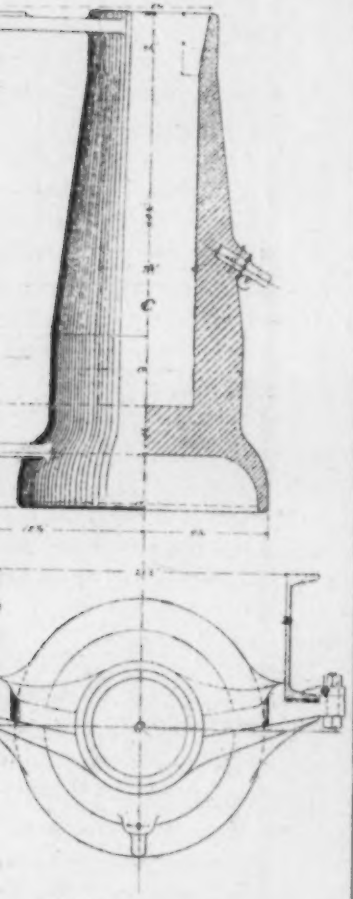
designed by

F.C.PRINDLE C.

DIMENSIONS ARE FINISHED

SCALE 3 INCH = 1 FOOT

SHEET No 3



DETAILS

42 Ft Wrought-iron

DER PILE-DRIVER

designed by

F.C.PRINDLE C.E.

SHEET No 3

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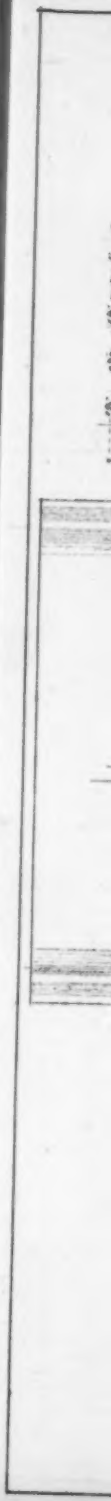
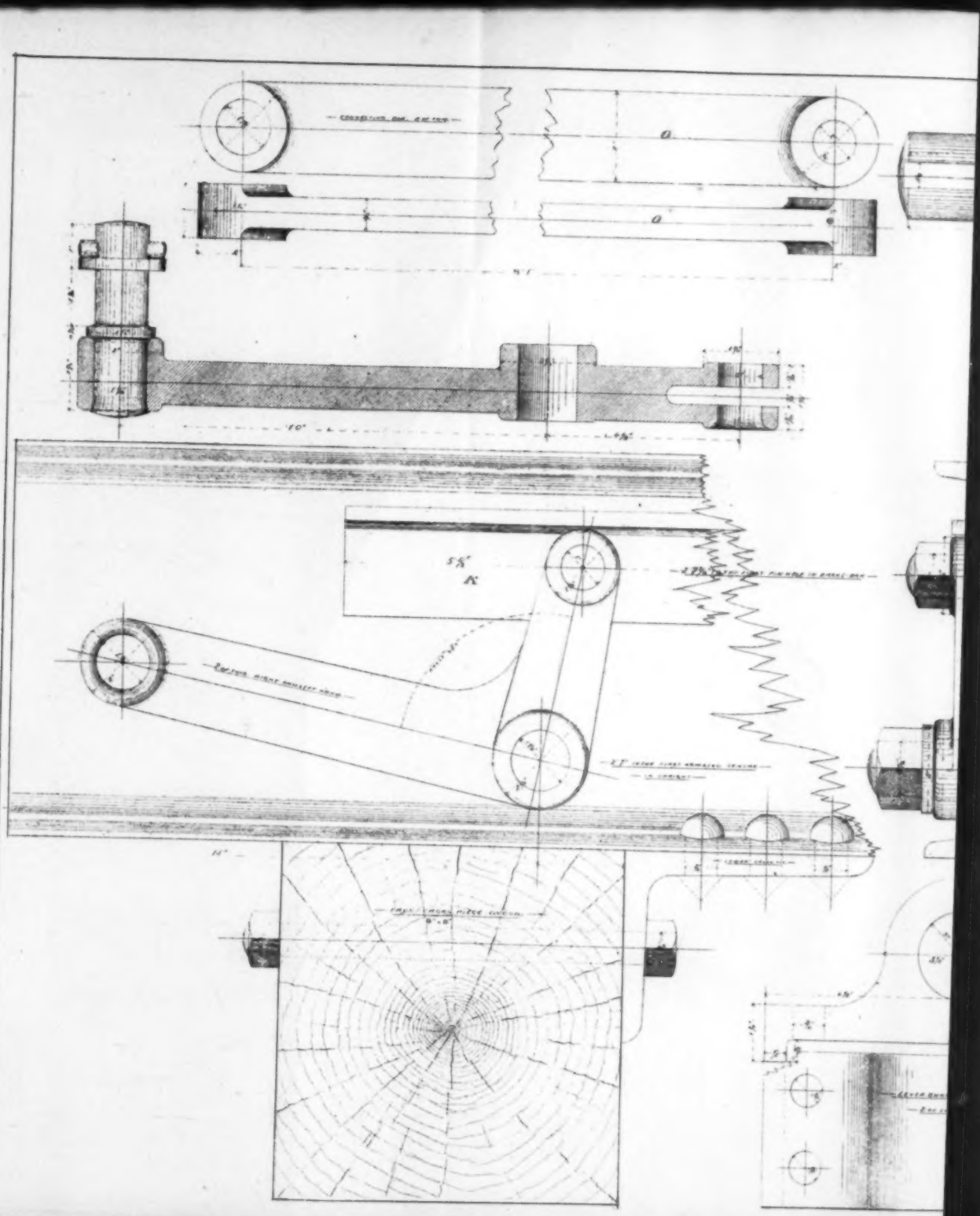
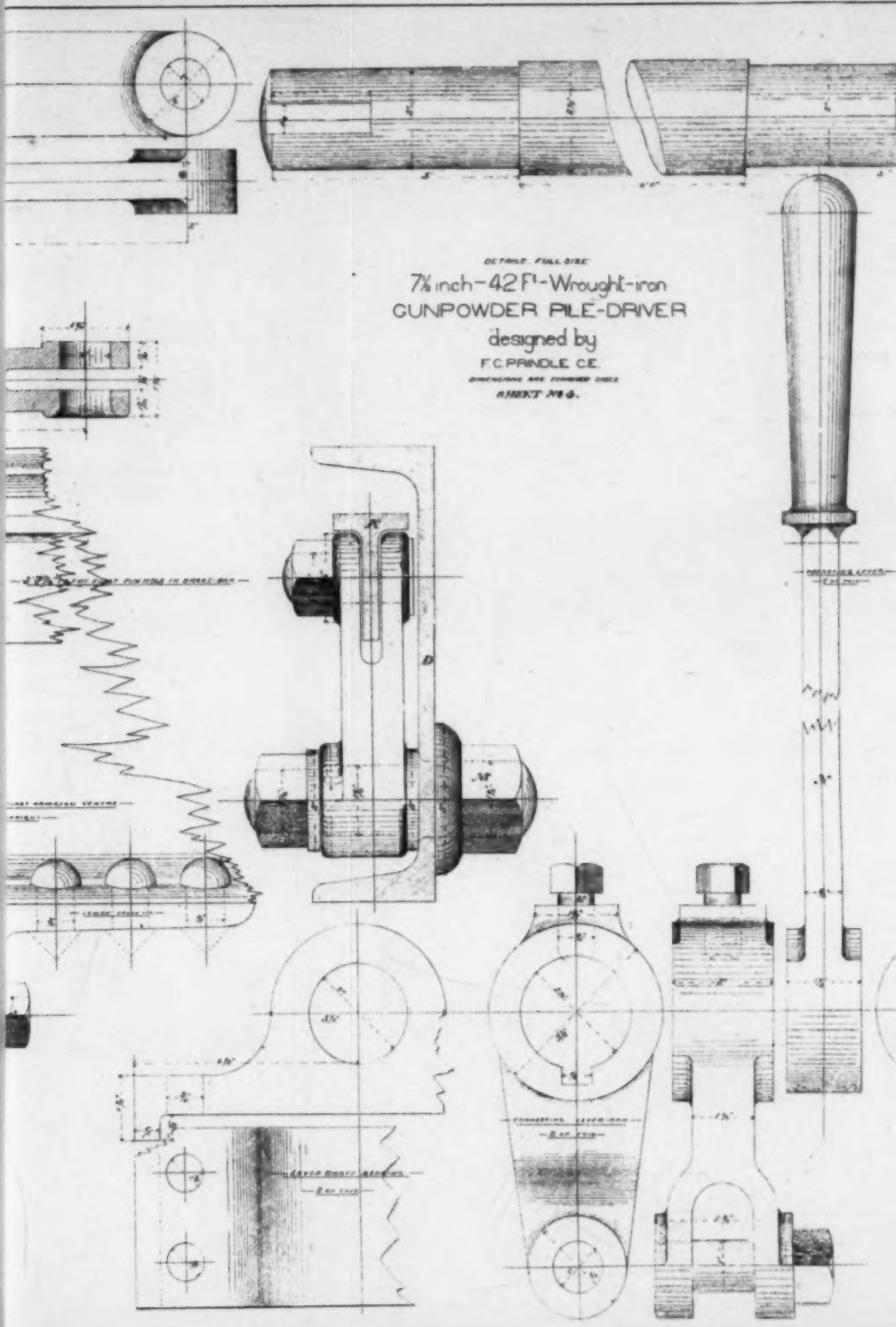
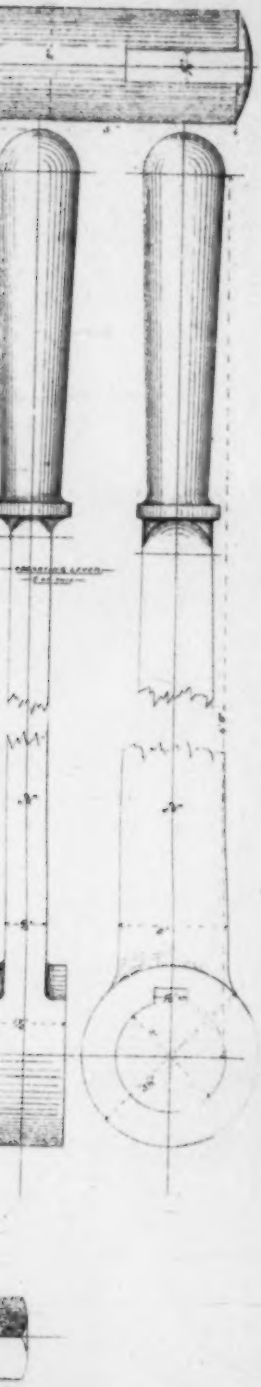





DETAILS. FULL SIZE.
7⅛ inch - 42 Ft - Wrought-iron
GUNPOWDER PILE-DRIVER
designed by
F.C. PRINDLE. C.E.
DIMENSIONS ARE FINISHED SIZES
SHEET No 4.



...ith for A. Parker, 123 S. 4th St. Phila.

brighter than at its inception, since previous to sinking the Detroit shaft there was a fear that very troublesome veins of water, supplied from the land and having a higher source than the river, might be met. For this reason the Detroit shaft was sunk first, as the borings on the Windsor side did not indicate such veins of water.

In the latter part of July, 1872, when the work on the Windsor end had progressed about 250 feet through, for the most part, very hard ground, some of which was blasted, a sudden irruption of sand and water occurred, which threatened to fill the tunnel out to the sump, and choke the pumps. To prevent this, a bulkhead was constructed near the face, but before it could be made sufficiently tight the workmen had to retreat some distance to make an apparently successful stand, and even this did not prove sufficient, so that a third and last bulkhead, still nearer the shaft, was put in. This state of things looked very discouraging, and it was, of course, impossible to tell the exact nature and extent of the source of the irruption, or how long it would continue. From the character of the water itself, as well as from other circumstances, it evidently did not come from the river, and there was reason to hope its flow would soon diminish. This hope was not disappointed, and about the 14th of August the face was again reached, the bulkhead (and 150 cubic yards of sand) having been removed. Regular operations were resumed, but after 30 feet of new tunnel had been built a fresh irruption of sand and water occurred, making it again necessary to put in bulkheads, and preventing further advance for four days more. By this time it was concluded that the source of the irruption must be a vein, and not merely a pocket of sand; still it was hoped that it might prove quite limited in extent, and soon be passed. On the 12th of September, after the work had been extended 47 feet further, a third irruption occurred. After another placing and removing of bulkheads, and taking out of sand, causing a delay of five days, regular operations were resumed, and 10 feet advance made, when a fourth irruption occurred.

By this time the contractors had become very much discouraged, and felt that to continue the drift on the same level would be ruinous to them, as the work was costing more than four times the price they received for it. Inasmuch as the work on the Detroit side had been extended about 1200 feet—sufficiently far to drain the lowest portion of the main tunnel—and as the principal object now remaining was to explore the ground through which the main tunnel was to be built, it

was decided to make a "lift-shaft" at the end of the drift on the Windsor side, and get into the ground through which it was proposed to construct the main work, thus avoiding, if possible, the irruptions which had become so troublesome. This was accordingly done, and a new drift started at a level 10 feet higher than that of the drainage tunnel. The ground was much easier to excavate, but the irruptions, which formerly came from the top of the excavation, now came up through the bottom, there being a vein of sand at the level of the top of the lower drift. This was not a quicksand, nor usually running, and was only brought in, when it did come, by the force of running water. On reaching a point about 370 feet from the shore shaft, an irruption occurred, which continued so long that it seemed as if further progress in that direction was impracticable, in so small a drift, with the ordinary means of tunneling.

Before describing the further steps taken at this end of the tunnel, it will be well to mention what had been encountered and done on the Detroit side. The work was carried on there without any serious difficulty, and at a satisfactory rate of speed, until a point 1110 feet from the shaft was reached. There the quantity of water coming from the bed-rock, immediately beneath, increased considerably. Gas had been more or less troublesome most of the way, sometimes making the men's eyes so sore that they had to quit work for awhile. When a distance of about 1180 feet had been reached the machinery for ventilating the tunnel proved inadequate, and some delay was occasioned by having to put in more. Before the ventilating apparatus was started again, a man went out to the end of the work, and returned without having been injuriously affected by the air, which he said was bad. He reported a sand leak at the face. Two others then went out to stop the leak, which they expected to do in a few minutes; but they never returned alive. When they had remained as long as was thought necessary and did not return, the foreman sent a man to order them back, if their eyes were affected by the gas. He returned and said that they were dead. Others went in for them, but were unable to get them out alive, although one of them showed signs of life when first reached. (It was only after several attempts, and at great risk, that their bodies were recovered.) Previous to this no one connected with the work had feared any fatal results from inhaling the gas, the greatest evil apprehended being sore eyes.

After the new ventilating apparatus was set in motion, regular operations were resumed, and the work was extended to a point 1220 ft.

from the shaft The influx of water here became so great as to require more powerful pumping machinery. It was thought best, however, not to require the contractors to incur this expense at the time, but to let them suspend work at this end until further developments were made at the Windsor side, where the prospect, as previously stated, was so discouraging.

At this juncture the contractors requested to be relieved from all further obligation to prosecute work under their contract, which the directors agreed to, on conditions not necessary to mention here.

It was then determined to carry on the work at the Windsor end by the day, by means of two parallel trial drifts, and to begin the second one at the shore shaft, at a level 10 feet above the grade of the drainage tunnel, leaving the latter to be used as a sand-holder in case of further irruptions. Thus it was hoped that, in either one or the other of the parallel drifts, some progress might be constantly made; experience having shown that a stream of sand and water flowing into the tunnel at one point would never be accompanied by a troublesome one flowing in at another. In fact, it was observed that water which flowed from an orifice which at first discharged sand as well as water, ceased flowing either shortly before or just when a new irruption occurred at the face.

The upper drift, for a distance of about 380 feet from the shore shaft, was easily constructed, in some cases upwards of 20 feet of progress being made in 24 hours. This drift was continued to the right of the old one, beyond the lift-shaft, and no irruption occurred in it until an advance of about 20 feet was made beyond the face of the old or first drift. Then an irruption occurred, and the water and sand ceased flowing into the old drift, which was extended 50 feet before the water returned to it and left the new one free. The latter was in turn extended about the same distance, when the water changed over to it. Thus the work was carried on alternately in the old and new drifts, when the directors, becoming discouraged at its slow progress and excessive cost, ordered it stopped. The actual advance in new ground during the last two months was only 64 feet, and the cost about $7500, or more than 6½ times the contract price.

Besides the discouragements connected with the work, the unusual severity of last winter caused such an interruption in the movement of freight across the river at Detroit, as to amount almost to "strangulation," certain and speedy relief from which was felt to be an absolute necessity; otherwise the already very heavy and constantly

increasing business of the two railways interested must be largely diverted to other channels.

The decided refusal of the Canadian Parliament, a few years since, to grant a bridge charter has been succeeded recently by the granting of one to a company whose road crosses a few miles below Detroit, on condition that Congress shall grant one also. The matter is now the subject of investigation by United States Engineers, who are to report before the next meeting of Congress.

While the construction of the Detroit tunnel, as a simple engineering problem, cannot seem otherwise than practicable to the members of the profession, especially in the light of the experience gained on the Thames tunnel, and similar works completed since, the advisability of constructing it, as a judicious expenditure of money, was left to be fully settled by the making of the drainage tunnel. The engineer believed, from the original borings, and from the earlier operations on the drainage tunnel, that the main work was not only practicable but advisable; later developments, however, throw much doubt upon its advisability.

It remains to answer several questions which will very naturally occur to members of the Society, such as—

1st. Why was not the character of the veins of sand, which gave so much trouble, revealed by the borings made before the work was begun?

The borings did frequently pass through small deposits of sand, but pockets of this material are so common in drift clay, that nothing is thought of them in ordinary tunneling. As already mentioned, fears were entertained that trouble from a great influx of water might be encountered in the Detroit end, but no such difficulty occurred there.

2d. Why could not the orifices through which the irruptions occurred be stopped?

This experiment was tried several times, but it always ended in making matters worse instead of better. If the influx was stopped at one point, it broke out at another. If the whole face was completely protected against it, the fresh joints in the masonry would be washed out. This will not be wondered at when it is stated that the source of the in-pressing water was ascertained, after the stoppage of the work, to be more than 100 feet above the bottom of the drainage tunnel.

3d. Why could not a shield have been used to advantage?

This was thought of, but experience, both in Chicago and elsewhere, had shown that shields, in such small drifts, through soft clay, are exceedingly difficult to keep in line. Such would have been especially the case on this work, where, after each irruption, the end of the masonry and, toward the last, the timbering, were so twisted and broken, laterally and vertically, as to require rebuilding in several instances.

4th. Could not the work have been carried on by the pneumatic process?

Besides the fact that no horizontal drift of any length is known to have been made in this manner, it will be sufficient to state, to those familiar with this process, that work executed under a pressure equal to 90 or 100 feet head of water is not only very expensive, but hazardous to human life.

Another reason for not excluding the sand permanently, if it could be done, was that by letting it come in till it ceased to flow of itself, the ground would be left in a much better state for the main work. This belief was confirmed by making the second and parallel drift, in which no irruption occurred until after all the old ground worked in had been passed.

A MEMBER—How was it ascertained that the source of the water was 100 feet higher than the tunnel?

MR. CHESBROUGH—The top of the shore shafts are 106 feet above the top of the drainage tunnel; after the work ceased entirely, the shaft was allowed to fill up, when the water rose to the top, and now flows over.

MR. MCALPINE—It is stated that the inflow of the water in these tunnels evidently came, not from the river, but from a higher source. When building the dry docks at Brooklyn, precisely the same result took place. We were 40 feet below the level of tide-water, and fresh water came in with a head of 50 feet—perhaps 100 feet—higher than that of the salt water.

MR. C. SHALER SMITH—Did this irruption come from below?

MR. CHESBROUGH—I am sorry I have not a section here. I am satisfied that it came from below. There was a vein of sand just above the top of the drainage tunnel, and when there was an irruption it seemed to come from that. The irruptions at first were rather from above, then we went up and obtained a rock grade on the Windsor end, and *there* the water pressed upward, and I think it came from the rock. I will give you another reason: At a place called Sand-

wich, below Detroit, where there are sulphur springs, the water frequently rises 30 or 40 feet above the river.

MR. C. SHALER SMITH—Almost the same circumstance happened in sinking one of the piers of the St. Charles Bridge by the pneumatic process. At about 50 feet below the surface, a sulphur spring was struck, which, from the manner in which the water rose in the caisson, had evidently a greater head than the river above it.

MR. CHESBROUGH—I have heard of several instances like that.

MR. BOLLER—You spoke of sulphur springs in the neighborhood, and suppose that the water which came in on you had a similar source; was it sulphur water?

MR. CHESBROUGH—Yes, sir; it was.

TRIAL OF THE WORTHINGTON PUMPING ENGINE, AT PHŒNIXVILLE, PA.

Editor of Journal of Franklin Institute:

DEAR SIR,—I send you a report of the trial of the new Worthington pumping engine just completed for the water-works at Phœnixville, Pa., forwarded me with other data by Mr. Robert Davies, one of the water-works committee of trial.

You will see that the duty of the engine was 70,422,306 lbs. of water raised one foot by 100 lbs. of coal.

This is much higher than that produced on the trial of the Belmont W. W. engine, and reported in the Journal of February, 1873, when the duty was given as 54 millions by one method (the actual duty) and 63 millions, calculated on a basis of 9½ lbs. of water per lb. of combustible.

The Phœnixville engine is one of Mr. Worthington's new style; one pump is worked by a high-pressure cylinder which exhausts into a tank; the steam from this tank works a low-pressure cylinder, which operates the other pump.

The indicator cards show that no expansion takes place in the cylinders, and yet the engine shows very great economy per lb. of coal; how much of this is due to the engine, and how much to the boiler, we have no means of knowing. The indicator cards show 16 H. P. for the high-pressure cylinder, and 23 H. P. for the low-pressure. Total, 39 I. H. P., or one I. H. P. per 2.44 lbs. of coal.

The actual or effective H. P. from water lifted was accomplished by 2.8 lbs. of coal.

The only exception which can be made by any one, would be that the trial, five hours, was too short. The *effective value* of the fire remaining at the end of a trial is a matter of judgment; Mr. Davies is of the opinion that the fire was better than at the commencement; and the same fire did actually run the pumps up to speed one hour after the official trial had ceased.

When we look at the facts, of the small dimensions of the engine; that it was fired by the regular fireman, and from the usual coal pile, and no deductions made for ashes and refuse, the result is very satisfactory. Deducting for ashes would make it little over two lbs. of coal per I. H. P.

Engineers who have given all their attention to short cut-offs and great expansion may find other roads to economy.

Subjoined please find the report referred to.

Yours, truly, EDW'D BROWN.

Philadelphia, Dec. 22d, 1874.

TO THE BURGESS AND TOWN COUNCIL OF THE BOROUGH OF PHŒNIXVILLE:

Gentlemen,—The undersigned, a committee appointed by your honorable body to test the capacity and duty of the Compound Horizontal Duplex Pumping Engine and Pumps, built by H. R. Worthington, of New York, for service at the Water Works in this Borough, beg leave respectfully to report—That in the performance of their duty as said committee, they met at the engine house of said water works, on Tuesday, December 2d, 1873, and there, in connection with Mr. Frank W. Jenkins, who represented the maker of the engine and pumps, proceeded to make the trial.

As your committee are informed, no fire had been under the boiler for three days previous to the trial; that the fire was only started under the boiler about 7 o'clock on the morning of the trial; consequently the walls surrounding the boiler were cold, and it was not until 10 o'clock that the steam was in condition to begin the trial. At exactly 10 o'clock, A. M., the trial was begun, and it was continued for exactly six hours. All the coal used was weighed either by or in the presence of one or more of your committee, the condition and thickness of fire, the quantity of water in the boiler, and the pressure of steam, were all carefully noted at the beginning and end of the trial, and your committee are satisfied that the fire was better and of as great thickness at the end of the trial as at the beginning; the depth

of water was ¼ inch in excess of that at starting, and the steam pressure 8 pounds per square inch greater.

Observations were made by your committee at each half hour during the trial, making in all thirteen observations as follows:

Time of Observation.	Pressure of Steam by gague.		Vacuum by gauge.	Register of counter.	No. of strokes since last registration.	Strokes per minute, by count.	Water pressure by gauge.	Length of stroke of pump.	Amount of coal consumed.	Water in boiler gauge.	Height of water pressure gauge above water in well.	
	Boiler.	Eng. room.						Inches.	Lbs.		Ft.	In.
10 A. M.	47	43	27¾	185136		49	73	24½		13¼	13.	3¾
10.30 "	47	43½	27¾	185507	371	48	73	24½		13½	"	"
11 "	48	45	27½	185862	355	52	73¼	24½		13½	"	"
11.30 "	48	45	26⅝	186236	374	50	73	24½		13½	13.	4¾
12 M.	48	45	26½	186608	372	49	73	24½		13½	"	"
12.30 P. M.	50	47	26¼	186996	388	53	73½	24½		13½	"	"
1 "	50	47	26¼	187405	409	54	73½	24½		13½	"	"
1.30 "	50	47	26½	187809	404	54	73½	24½		13½	"	"
2 "	49½	46½	26½	188212	403	54	73⅝	24½		13½	"	"
2.30 "	49½	46½	26½	188612	400	52	73⅝	24½		13½	"	"
3 "	50	47	26⅝	189028	416	52	73½	24½		13½	"	"
3.30 "	52	49	26⅝	189430	402	54	73¾	24½		13½	13.	5¼
4 "	50	47	26⅝	189831	401	54	74	24¼	570	2	13.	5½

Number of revolutions of the pumps during the trial, 4695; average stroke of pumps, $24\frac{3}{16}$; number of pounds of coal used on trial, 570; capacity of pumps per revolution, 54,240 gallons, at two feet stroke. Number of revolutions equated to two feet stroke,

$$\frac{4695 \times 24\ 3\text{-}16}{24} = \frac{113560}{24} = 4731 \times 54.24 = 256{,}609$$

gallons discharged. Average distance of water below gauge, 13 feet $4\frac{3}{4}$ in. Pressure of gauge average, 73.384 pounds. Height equal to a pound in column of water of one square inch, 27.70 inches nearly, then

$$\frac{73.384 \times 27.70 + 13 \text{ ft. } 4\frac{3}{4} \text{ in.} \times 12}{12} = \text{height lifted in feet } 182.79.$$

Actual difference in level between the water in the Schuylkill at the pump, and the average level in the water basin during the pumping was 185.59 feet, showing a variation against the pump of 2.80 feet, in addition to any friction in the pipes, probably not less than two feet additional.

Quantity of water pumped during the trial as determined by the measurements at basin before and after the trial, was 258,316 gallons.

By the contract with H. R. Worthington, the maker of the pump, its capacity was to be equal to the supply to the basin as located of 1,000,000 of gallons of water in 24 hours, and its duty was to be 45,000,000 pounds of water raised one foot high with the consumption of 100 pounds of coal.

One gallon of water weighs 8.3388 pounds.

By the above data it will be seen that the capacity was

$$\frac{226{,}609 \times 24}{6} = 1{,}626{,}436 \text{ gallons in 24 hours.}$$

The pumps actually raised as per mode of measurement provided for in the contract, 256,609 gallons, weighing 8.3388 pounds per gallon, = 2,139,811 pounds 182.79 feet high = 391,136,052 pounds 1 foot high.

As this work was done with the consumption of 570 pounds of coal, the equation becomes

$$\frac{391{,}136{,}052 \times 100}{570} = 68{,}620{,}360 \text{ pounds of water lifted 1 foot with}$$

100 pounds of coal, or the whole put in the equation as per contract

$$\frac{227882 \times 2 \times 4695 \times 182.79 \times 100}{570} = 68{,}620{,}360 \text{ pounds, the}$$

contract calling for but 45,000,000.

The fire remaining after the trial actually ran the pumps up to contract speed for one hour, the pumps making in the time 765 revolutions and elevating to the reservoir nearly 42,000 gallons of water, or at the rate of 1,008,000 gallons in 24 hours, showing that the fire was not exhausted during the test.

In this connection your committee take much pleasure in stating that in their opinion Mr. Worthington not only carried out the letter, but the spirit of the contract in furnishing the pumping apparatus above referred to; the whole seems perfect in all its parts, the mechanical details appear to be unexceptionable, leaving apparently nothing to be desired in the way of improvement or addition to make it more complete.

It will be seen from our report that to pump 1,000,000 gallons in 24 hours only requires a speed of piston of about 51 feet, while the

pumps will run easily 75 feet per minute, and would perform reasonably well even up to a speed of 90 feet per minute, or over 75 per cent. in excess of the trial speed, but your committee think it would not be advisable to run the pumps over 50 per cent. in excess of the trial speed. In other words, they think the limit of capacity of the pumps would be reached at about 1,500,000 gallons in 24 hours.

Your committee think it but fair to state, that they believe Mr. Worthington entitled to the actual height pumped, with the addition of two feet for friction, which will give an actual duty of

$$\frac{68{,}620{,}360 \times 187.59}{182.79} = 70{,}422{,}306$$ pounds of water raised one foot with 100 pounds of coal.

The measurements made at the basin were made with much care, and were intended to check the work of the pumps, and your committee are free to say that, from the very large duty shown, they would have been inclined to doubt whether there had not been some leakage at the pumps; as it is, they have no hesitation in saying that they have no doubt the actual quantity of water registered was forced into the reservoir on the trial.

The coal used on the trial was taken without selection from the supply on hand which was provided for general use.

Respectfully submitted,

JOHN GRIFFEN,
GEORGE WALTERS,
ROBT. H. DAVIES,
} *Committee.*

NOTE —The plunger of high pressure pump is 12 inches, and the piston rod 2½ inches in diameter.

The plunger of low pressure pump is 14 inches and the piston rod three inches in diameter. Which give the capacity per revolution of both pumps 54.24 gallons; the stroke being two feet.

NOTE RELATIVE TO THE ESTIMATION OF THE COMMERCIAL VALUE OF COALS CONTAINING LARGE QUANTITIES OF ASH.

By Prof. R. H. Thurston.*

A question has lately been presented, involving the determination of the effects of an excessive amount of ash in modifying the commercial value of anthracite coal. The method of determination adopted will probably be of interest, since there is at present no generally accepted and standard method in use among engineers.

The value of a coal depends upon many circumstances. The proportions of uncombined carbon and hydrogen, the form in which hydrocarbons are contained in the fuel, the physical characteristics of the coal, and the chemical constitution and the percentage of the ash, all affect its market value. In individual cases, also, the form of heating or other apparatus in which the coal is burned influences the relative value of fuels equally good in other respects, one steam boiler, for example, being well adapted for anthracite, and another for bituminous coal.

Where the difference between two coals lies principally in their relative percentages of ash, the comparison is easily made.

The anthracites contain so little other combustible matter that, as shown by Professor Johnson,‡ their calorific value is proportional to the percentage of contained carbon, very nearly. Their commercial value is somewhat different.

The depreciation produced by presence of non-combustible matter occurs in the following ways:

First. A certain amount of carbon is required to heat the whole mass to the temperature of the furnace, of which a large part is lost. It follows, therefore, that a coal containing a certain small quantity of combustible would have no calorific value, and, consequently, would be worthless in the market.

Second. The presence of a high percentage of ash in a fuel checks combustion by its mechanical mixture with the combustible portion of the coal. A coal will, hence, have no commercial value when the proportion of refuse reaches a limit at which combustion becomes impossible in consequence of this action.

Third. The cost of transportation of ash being as great as that of transporting the combustible, the consumer paying for ash at the

* From Scientific American (communicated by the Author.)

† Report to the Navy Department on American coals.

same rate as for carbon, and also being compelled to go to additional expense for the removal of ash, these facts would also determine a limit beyond which an increased proportion of ash would render the fuel valueless.

Fourth. The determination of the financial losses due to increased wear and tear of furnaces and boilers, of incidental losses due to inequality or insufficiency of heat supply, and to the many other direct and indirect charges to be made against a poor fuel, will also indicate a limit which will have a different value for each case; but which will, in most cases, be difficult of even approximate determination.

The determination of the minimum proportion of combustible, under the first case, is thus made, assuming this heat to be entirely wasted.

The specific heat of ash is usually nearly 0·20. Let X represent the percentage of ash which is sufficient to render the coal valueless. Then, since each pound of carbon has a heating power of 14,500 thermal units: $14{,}500\ (100 - X) = A$, represents the available heat of a unit in weight of the fuel.

$100 \times 0{\cdot}20 \times 3{,}000^\circ = B$; represents the heat required to raise this same amount of coal to a temperature equal to that of the furnace, which is here assumed at 3,000° above the surrounding atmosphere.

Since these quantities, A and B, are equal: $14{,}500\ (100 - X) = 100 \times 0{\cdot}2 \times 3{,}000$, and $X = 96$ per cent.

The minimum quantity of fuel permissible is, therefore, four per cent. where the first consideration only is taken into the account.

The influence of the second is at present indeterminable in the absence of experiment.

The cost of transportation of ash to the consumer, as a part of the fuel, has no bearing in the determination of its value to him. The removal of ash is a tax upon the consumer which may be considered as the equivalent of the loss of a certain weight of combustible received. Since this cost fluctuates with the market value of coal, and since its amount is determined by the same causes, it is easy to make the statement in that form.

This cost is about ten per cent. of the value of coal, weight for weight, and is therefore assumed at ten per cent. of the proportion of ash found in the coal.

The losses, direct and indirect, coming under the fourth head, vary

greatly and are sometimes very serious. An approximate estimate for an average example is taken, and is considered to be equal, at least, to a percentage of the total value of coal, in utilizable carbon, which equals one half the percentage of ash.

Comparing two anthracites, which we will suppose to contain, respectively, fifteen and twenty-five per cent. ash, eighty-five and seventy-five per cent. carbon, the first being a well-known standard coal, selling in the market at six dollars per ton, we may, using this system of charging losses against equivalent values in combustible carbon, determine the proper commercial value of the second kind.

First Example.—From the 85 per cent. carbon:

Deduct for heating to furnace temperature, ...	0·040
" transportation of refuse, 10 per cent. of 15, .	0·015
" other losses, 50 per cent. of 15, ...	0·075
Total, ...	0·130

Leaving available and valuable carbon $85 - 13 = 72$ per cent.

Second Example.—From the 75 per cent. carbon:

Deduct for heating to furnace temperature, ...	0·040
" removal of ash, 10 per cent. of 25, ...	0·025
" sundry losses, 50 per cent. of 25, ...	0·215
Total, ...	0·190

Leaving valuable available carbon $75 - 19 = 56$ per cent.

Finally, if \$6.00 is paid for 72 per cent. available combustible, for 56 per cent. we should pay $\frac{56 \times 6}{72} = \$4{\cdot}66\frac{2}{3}$.

Taking a third example, in which the fuel contains the unexceptionally large proportion of 30 per cent. ash, we should, by similar method, proceed as follows, deducting from the seventy per cent. carbon, as before, the estimated charges against it.

Third Example:

Deduct for heating, ...	0·040
" removal of ash, 10 per cent. of 30, . . .	0·030
" sundry expenses, 50 per cent. of 30, . .	0·150
Total, ...	0·220

Leaving available carbon, $70 - 22 = 48$ per cent., which would be worth $\frac{48 \times 6}{72} = \$4{\cdot}00$.

Had the first coal had a market value of seven dollars per ton, the second and third would have been worth, respectively, $5·44\frac{1}{2}$ and $4·66\frac{2}{3}$.

This method is evidently largely empirical, and its results are but approximate. It is, however, simple and easily applied, and will often be found of use in the absence of more precise means of determination. Those whose experience may differ from that of the writer can readily modify the values for themselves.

Steven's Institute of Technology, Hoboken, N. J., December, 1873.

Reduction of Silver Salts by Hydrogen.—Dr. Russell, F. R. S., communicates the fact to the Chemical Society, that thoroughly washed and purified hydrogen causes a precipitation of metallic silver from a solution of silver nitrate, the precipitation occurring much more readily in saturated than in dilute solutions. The gas employed was usually procured by the action of a saturated solution of copper sulphate on zinc, or by the action of water on powdered zinc and tin. After it has passed for about half an hour through a saturated solution of the silver salt, a dull greyish deposit is produced, which is succeeded by a bright crystalline deposit. A clear solution, through which hydrogen had been passed, became turbid and gave a precipitate of silver when heated. Similar effects were obtained when the solution was exposed to an atmosphere of hydrogen instead of causing the gas to bubble through it. The author has conclusively proved that these phenomena are caused by the hydrogen replacing the silver in the silver nitrate, producing hydric nitrate. But a secondary reaction also takes place between the nitric acid and the precipitated silver, which results in the formation of silver nitrate. Dilute solutions of nitric acid have little or no action on silver, as hydrogen precipitates silver as readily from a nitric acid solution as from an aqueous solution. It has long been well known that hydrogen will precipitate from their solutions the platinum metals and gold, and the above observations with regard to silver add to its importance as a reducing agent.

Chemistry, Physics, Technology, etc.

ON ARTIFICIAL FUEL.

A paper read before the Franklin Institute, at the stated meeting, January 21, 1874.

By E. F. Loiseau.

It is so evident that great advantages would be gained by coal operators, and by the public generally, from the utilization of what is known as *coal dust, slack, waste,* or *culm,* that it is to be wondered that manufactories to transform this worthless material into a marketable fuel are not erected everywhere in the mining regions. The immense accumulations of coal-waste to be found in those regions are really a nuisance to the inhabitants and an eye-sore to the traveling public.

It is generally admitted that, on an average, from 40 to 50 per cent. of the entire coal production, both in this country and in Europe, is converted into dust or waste, the amount of which will be in proportion to the brittleness of the mineral and to the different operations to which it is submitted, in order to classify it by sizes for the market.

The utilization of this waste has been a problem which scientific and practical minds have tried to solve for a number of years. Partial results have been obtained by which a certain amount of the waste of coal mines has been utilized, and this only in Europe, where a gradual and constant increase in the cost of the natural coal has given to the manufacturers of artificial fuel a fair chance of profit, but it must be admitted that, compared with other branches of industry, the progress made in the utilization of coal waste has been very slow. The enormous increase in the cost of coal in England, France, Germany and Belgium during the last three years, has, however, brought again before the public, and this time prominently, the question of utilizing the waste created everywhere that coal is handled. The question, then, at the present day, which concerns the manufacture of artificial fuel, as we call it, or of patent fuel or agglomerated coal, as it is called in Europe, is not one of prejudice, but of necessity, for the waste of the coal resources, both in this country and abroad, has at last assumed such gigantic proportions, that some efficient means must be found for the economical utilization of the small coal which is now unavoidably made, even under the very best known systems of working coal.

Bituminous coal dust will coke well, and it is much used for that purpose, but the demand for coke not being in any way equal to the the supply of bituminous small coal from which it might be made, a great proportion of the latter is left underground, and ultimately becomes lost beyond all possibility of future recovery. A small proportion of bituminous slack is used by blacksmiths and even on peculiar grates for engineering purposes, but the largest part is, as said before, left underground, or thrown into rivers or piled up around the mines, occupying ground which might be better and more conveniently used for other purposes.

The waste created in the preparation of anthracite coal for the market is considered entirely worthless. It may be estimated that from 25 to 30 per cent. of the entire production of this coal is reduced to dust by the operation of the breaker alone. The vast, unsightly mounds of coal dust in the anthracite coal regions have become a familiar feature of Pennsylvania's landscape; they are increasing in number and in size every day, and it is estimated that the quantity of said waste exceeds to-day thirty millions of tons.

Although several establishments have been created in France, England and Belgium for the purpose of converting the coal waste into marketable fuel, that branch of industry is at present quite in its infancy. France has to day 28 and Belgium 9 manufactories of artificial fuel. In England, the principal seat of those manufactories is in South Wales, whence steam coal is shipped chiefly for foreign ports.

Coal dust can be manufactured into solid lumps in two different ways: by simple compression without the addition of any cementing material, or by agglomeration with cements.

In England, Messrs. Bessemer, Rees and Buckwell, and in France, Messers Baroulier, Evrard and Loup have patented different processes for the compression of bituminous coal dust into solid lumps without cements. The coal manufactured had a great heating power, but it could not bear handling and transportation.

Bessemer, heating previously the bituminous slack until it was brought to a plastic state, forced it, by a piston, into a long tube whose diameter was gradually reduced and from which the compressed coal was forced in a continuous cylindrical shape. By means of a revolving knife, the fuel was cut in sections of any required length, as fast as it was forced out of the tube. This process required very powerful machinery. Bessemer was compelled to reduce gradually

the length of the tube and to increase its thickness, as it bursted very often. The process required a large amount of natural coal to heat the dust to a pasty mass, and while being heated, it eliminated from the coal the greatest part of its volatile constituents. The application of Bessemer's process has long ago been abandoned.

Buckwell and Evrard compressed the bituminous waste into moulds without heating it previously. Although a powerful pressure was applied to the fuel the product could not bear handling.

Baroulier used circular iron moulds of a certain depth, open on top and at the bottom. These moulds were filled with coal dust and this dust compressed by hydraulic pressure; more coal was then added, this again compressed, and so on, until the moulds were completely filled. The moulds were then placed, side by side, on an iron plate, in a car having perforated sides and bottoms; another plate was then placed over all the moulds and bolted to the one on which they rested; another series of moulds were placed side by side, on that second plate, covered by a third plate, securely bolted to the second one, and so on until the car was filled. This car was then taken to an oven heated to 400° Fahrenheit. The plates between the moulds prevented the expansion of the coal and the escape of the volatile matters contained in it. This process, although a real improvement on Bessemer's process, had some of its defects; it required much labor, a large quantity of moulds, plates, iron cars, etc., which had to be replaced very often, and it also consumed a large amount of coal. The expenses were so excessive that the manufactured fuel could not be sold in competition with the natural coal. The establishment erected by Mr. Baroulier at Gangreneuve, near St. Etienne, France, was in operation only two years, 1857 and 1858.

These are the only serious attempts which have been made to convert bituminous coal dust into solid fuel without cement. Rees took out an English patent for a process similar to Baroulier's. He did not meet with more success than my countryman did.

Among the numerous cements which have been patented for the manufacture of artificial fuel are to be found the strangest substances, such as *spoiled flour*, *blood*, *gum arabic*, *animal and vegetable oils*, *cow dung*, *rakings of roads*, *sweepings of houses*, *chalk*, *common salt*, *sal ammoniac*, *sulphur*, *solutions of glue*, *alkaline silicates*, *alum*, *copperas*, etc., etc. It is unnecessary to add that of these singular materials none have ever been brought into practical use.

Among the cements which have been used to a certain extent may

be cited *rosin, asphalte, petroleum, coal tar* and its derivative *fluid*, and *dry pitch, lime, plaster, starch* and *clay.*

Professor A. S. Bickmore, in a very interesting paper on "Coal in China," read before the American Association, says that "from time immemorial, in the north of China, coal is ground to dust and mixed with clay, that it may burn more slowly."

In 1603, a pamphlet entitled "A new, cheap and delicate fire of coal balls," was published in London by Sir Hugh Platt. This gentleman recommended for use in common fire-places, a mixture of coal and clay, moulded by hand in the shape of *balls.* He also used another mixture which consisted of coal dust, tanner's bark, sawdust and cow-dung. The preparation of the materials with water and the moulding of the composition into balls, by hand, is fully described in that pamphlet.

Another pamphlet, also published in London, in 1679, and entitled "An excellent invention to make a fire," contains the following recipe: "Take three parts of the best Newcastle coal, beaten small, one part of clay; mix these well together into a mass with water; make thereof balls, which you must dry very well. This fuel is durable, sweet, not offensive by reason of the smoke or cinder as other coal fires are, beautiful in shape, and not so costly as other fire, burns as well in a room even as charcoal."

In an article on the coal basin of Eschweiler, Mr. Clère, a French engineer of great reputation, states that "at Liège, (Belgium,) coal dust is mixed with clay, pressed by hand in the form of balls, dried in the sun and stored away for domestic use. That kind of fuel is there called *Hochets.* I can add to this, that even to this very day not only at Liege, but everywhere in Belgium, coal dust is used in the same manner.

There exists in Belgium a certain class of working women who earn a scanty living by converting the coal dust into solid fuel. They call at every house in front of which a load of coal dust has been dumped, offering their services. These poor creatures can be seen daily in the streets, always two or three together, each one of them pushing a wheelbarrow loaded with clay, in which stands a shovel. They try their best, if the house is occupied by people in easy circumstances, to obtain a little more than the price which is usually paid to them. As soon as the price is agreed upon, they go at work in earnest; the coal dust is shovelled all around so as to form a circular bed of about one foot in thickness. From 25 to 30 per cent. of clay is diluted

with water and sprinkled over the coal, which is well mixed with the clay by means of the shovels first. Then, putting on wooden shoes and slightly lifting their skirts, they commence to trample upon the coal, turning round the coal bed from the circumference to the centre, and back again from the centre to the circumference, following each other like ducks. When the whole surface of the coal bed has been trampled upon twice, the mixture is turned over with the shovel, and the trampling recommences. After five or six operations of the kind have been gone through, the coal and clay have been worked to a plastic mass. This is piled up in a heap, and, seating themselves on their wheelbarrows, these poor women proceed to compress the fuel in the shape of balls, by hand. These balls are then dried in the sun, after which they are ready for use.

This very primitive and original way of mixing and compressing coal dust into lumps has never been patented.

In some parts of Germany, the trampling on the coal is done by men on horseback. In the Rhine regions, the mixing of clay with coal is an affair of constant occurrence. Many a traveler has opened his eyes on seeing a bushel or two of clay dumped with every cart-load of coal, and carefully mixed in with it by the attendant coal-heaver. But he is still more surprised to see his servant gravely empty a pail of water into his coal-box, together with the morning's supply of fuel. The coal is mostly slack, and the fires do not burn well if the coal is dry.

At Ham-sur-sambre (Belgium), in 1859, under the direction of Mr. Darbois, machines, invented by Mr. David, a French engineer of merit, were erected for the purpose of manufacturing, by mechanical pressure, solid lumps from semi-anthracite coal dust, mixed with 15 per cent. of clay. With these machines, lumps of cylindrical shape were pressed, also cylindrical lumps with perforations half an inch in diameter, through the centre. These machines were very expensive, and their production was very limited. In 1861, they were replaced by cheaper and more productive machines, invented by Mr. Martin from Liege (Belgium). These machines, making egg-shaped lumps, met with more favor, as the product was very similar, to the lumps pressed by hand. Martin's press is still in operation at Ham-sur-sambre.

At Tamines-sur-sambre (Belgium), in 1862, under the direction of Mr. Cavenaile, the company of the "Charbonnages réunis de la Basse sambre" (united collieries of the low sambre), of which I was

at that time the general agent, erected also Martin's machines to convert the coal dust into egg-shaped lumps, by using 18 per cent. of clay as cement. Martin's press made only one lump at a time; its length was 6 inches, and its diameter in the centre 4 inches. The feeding was very defective. This little model gives you an idea of Martin's press. Two rollers, having on their periphery one-half of an egg-shaped mould, revolve in opposite directions. In a hopper, placed above the rollers, is thrown the coal dust and clay, previously worked into a plastic mass. It was expected, at first, that the mixture, by its own weight, would fall between the rollers; but it did not, and two men had to be employed to force the mixture between the rollers. These men, by means of pounders, would alternately pound the materials through the hopper, while a third one was shovelling the plastic composition into it. As this work was very fatiguing, the men had to rest every half hour, and were replaced by another set of men, who worked also half an hour and rested, while the first men resumed work, and so on. The last improvement in the feeding part was to place, in the centre of the hopper, a vertical screw to force the mixture down. It seems that in 1867 some more improvements were added and patented by Simon Baudry, from Tamines (Belgium), both to the compressing and to the drying apparatus. In Martin's process, the lumps of fuel would be delivered from the rollers on a short endless belt, from which they fell into very open-worked baskets. When filled, these baskets were carried away by boys and placed on shelves, under a shed, where the coal dried by simple exposure to the air. The roof of that shed was composed of sections of water-proof canvass, which were rolled up during fair weather. This slow and very imperfect method of drying economized fuel, but required a large number of boys.

Baudry invented a drying oven, with shelves all around; the fuel coming from the press would fall on perforated sheet iron trays instead of falling into baskets, and these trays were placed on the shelves in the oven. It required two hours to dry the fuel. The oven was then opened at both ends, and as fast as the trays containing dry fuel were removed from it, they were replaced by others containing freshly moulded fuel, which had been temporarily piled up near the oven. During this operation, the doors being open, the interior of the oven cooled down gradually, the work of removing its contents and of filling it anew had to be done very rapidly, and required also a large number of boys. Labor being relatively cheap in

Belgium and coal selling high, no improvements have been made to suppress unnecessary handling. Notwithstanding the defects of Baudry's process, it is still applied in Belgium, the product containing 18 per cent. of clay and not being impervious to moisture. The large percentage of clay and the fuel not being able to stand exposure to the weather are the greatest obstacles to the development of the manufacture of artificial fuel by the use of clay as a cement. Mr. Henry Gerondeau from Liege (Belgium), in an article on the agglomeration of coal dust, published in 1861, says that "if the proportion of clay could be reduced to a small percentage, and the product be made impervious to moisture, clay, which is the best and the cheapest, would undoubtedly supersede all other cements."

As I have said before, asphalt, rosin and petroleum have also been used as cements, but these materials have been found wanting in cohesive property, and also too expensive. Coal tar and its derivative, fluid pitch and dry pitch, have been the most extensively used.

The idea of mixing coal dust with coal tar originated with Peter Davey, an Englishman, who, in 1821, took out an English patent for what he describes as "consisting in an improved preparation for coal for fuel, which I call gaseous coke, and which is made of very small coals, mixed with coal tar (either in a pure state, which is best, or combined with naphtha and these other ingredients with which it is generally found impregnated), and then cemented together by the application of heat, in the form of large lumps or cakes, for the purpose of fuel." The mixture is pressed into moulds, which are placed for four hours in an air furnace heated to 350° Fah.

This same Peter Davey had obtained, 21 years before, in 1800, an English patent for an improved fuel, which he describes thus: "Small coals are mixed with charcoal or wood, breeze, turf, tan, saw-dust, cork-cuttings, peat, or other inflammable ingredient or ingredients. These materials are then well mixed and put into kilns, ovens or other furnaces, either dry or moistened, and, by means of dampers, slides, vent or air holes, or other contrivances, the heat is so regulated as to be equal to cementing the materials without destroying them."

This was rather a singular mixture of ingredients, but Peter Davey persevered in his researches, and during the 21 years which elapsed between the dates of his two patents, God only knows what dreadful mixtures that man must have tried.

During those 21 years no patents were applied for in England, and

two only were issued in France—one to a Mr. Quest, June 18th, 1810, for a mixture of coal dust and clay, and another to a Mr. Burette, June 12th, 1811, for compressing bituminous coal dust without cement. Peter Davey, then, may be considered the father of the artificial fuel industry.

From 1821 to this day a considerable number of patents have been issued, both in this country and abroad, either for so-called new processes or for the machines to apply them.

Coal tar was first used in France by Ferrand and Marsais. Their first experiments commenced in 1832, but, after a great many unsuccessful attempts, Mr. Ferrand having died, Mr. Marsais abandoned coal tar and tried fluid pitch. This was a successful stroke. He erected, in 1842, a factory at Berard, near St. Etienne, which was in operation during three years. He then removed his establishment to Gisors, where the coal company of St. Etienne is still manufacturing artificial fuel by Mr. Marsais' process, and that in the same factory erected by him 28 years ago.

Among the inventors who have really improved the means of manufacturing artificial fuel, by using either coal tar, fluid pitch or dry pitch, the names of Grant, Rathwell, Cooke, Wylam, Warlich, Dobrée, Moreau and De Haynin are prominent.

Fluid and dry pitch formed a good cement for bituminous and semi-bituminous coal dust, but it did not succeed as well with anthracite and semi-anthracite waste, which is mined in South Wales and in some parts of France and Belgium. Before the cement is consumed the bituminous artificial fuel is coked, and consequently it does not crumble in the fire. It is not the same with anthracite or lean coal dust. When cemented with coal tar or pitch, or any other resinous material, the cement consumes in the fire more rapidly than the coal, and the particles of coal, having lost their adhesive coating, crumble in the fire and fall through the grates without being consumed.

Resinous materials expand when burning, while clay, on the contrary, contracts progressively when submitted to elevated temperatures. Clay, used alone, would not have given a fuel impervious to moisture. It was supposed that, by mixing clay and pitch with the coal dust, the fuel manufactured would not only be waterproof, but would remain in the fire, without crumbling, until consumed, the shrinkage of the clay compensating for the swelling of the pitch.

Among the experimenters in that direction we have men who have really improved the manufacture of artificial fuel. The most eminent

of those inventors are Chabannes, Sunderlandt, Stafford, Oram, Geary, Goodwin, Mohum, Sterling, Albert, Newton, Holcombe, and one of the great Smith family.

All these attempts were unsuccessful. The presence of pitch in the fuel made it unfit for domestic use, and the clay impaired its combustible character for manufacturing purposes.

Patents were also granted to several inventors for a mixture of bituminous and of anthracite coal dust and coking the mixture. The first one of these patents was granted, in 1823, to John Christie and Thomas Harper, in England.

The result was the same as with Bessemer, Baroulier and others. The machinery was too expensive and the product was not marketable. The coke had no density, it was very porous, owing to the fact that the particles of anthracite would not unite with the bituminous and remained in a loose state in the cells of the coke. It burned well enough, but it was rapidly consumed, and could not bear handling

In 1838, April 26th, a patent was granted in England to Thomas Joyce, of Camberwell, for "certain improved modes of applying prepared fuel for the purpose of generating steam and evaporating fluids, the fuel to be used in chambers or furnaces, to be wood, coke, coal, charcoal or other fuel, prepared, chopped or broken into small pieces, so as to insure its falling down the fuel chamber, as the lower part of the fuel is consumed. It may be saturated with an alkali solution."

The combustion chamber consists "of a vertical cylinder, with a grate and apertures to support combustion at the bottom; it is filled with fuel which only burns at the lower part, the upper part falling down as that below burns away; the flame and smoke pass out through side passages surrounded by the water in the boiler."

This same inventor, on the 12th of November, 1838, obtained also a patent in this country.

The United States patent seems to have been confined to the fuel as used in a stove for heating rooms, etc. The invention made much noise at the time, and was considered a real improvement by many persons eminent in chemical science, but the plan was long since abandoned, and considered as an utter failure. The proposed fuel in this patent consisted of charcoal heated with potash, and the stove was to be without a pipe, the products of combustion all escaping into the room. The carbonic acid was to combine with the potash, and thus to prevent all injurious effects from it.

The English patent of Thomas Joyce contained, evidently, the germ of the self-feeding anthracite stoves in general use to-day.

In 1845, Richard Archibald Brooman obtained an English patent for "mixing coal waste with india rubber and gutta percha combined, or each of these alone." This was quite an elastic cement.

The most singular patent ever issued, was granted in 1840 to Thomas Kerr, of England, for a new composition for artificial fuel and other purposes. This composition is formed, first of the "rakings of roads, or streets, or other public ways, or the sweepings of houses, offices and other buildings, or of the ashes of coal or other fires, or of small coal, culm, breeze, or of river or sea sand or of free stone, or other stones pounded into dust, or of any other mineral or vegetable substance in a state of dust or powder.

Secondly, of chalk or any other similar calcareous substance of a drying and retaining nature, ground into a fine powder.

"Thirdly of tar, or pitch, or oil, or rosin, or some other substance of the like bituminous, fatty, or inflammable nature, such as the common archangel tar, in the same state as imported, coal tar as it comes from the gas works, the pitch that is manufactured from coal after the naphtha has been extracted, whale oil, linseed oil and other oils, and,

"Fourthly, simple clay or common salt. These ingredients described under these four heads are combined in a variety of proportions and used for fuel, and * * * for an infinity of other purposes."

Now, what on earth can those other purposes have been.

Some Americans, or naturalized Americans, seem to have been as erratic as this Englishman was. I find three patents granted in 1865 for the following compounds:

To Henry Redlich, June 27th.

Coal dust, . . .	4 parts.
Cow dung, . . .	3 "
Blood, . . .	1 "

To Chas. Korff, July 4th, one week after Henry Redlich.

One ton, . . .	Coal dust.
One gallon, . .	Blood.
One gallon, . . .	Water.

Such a patent granted on the anniversary of American independence. This Korff had evidently contracted his disease from Redlich.

To Samuel D. Hovey, October 24th.

100	parts,	Coal dust.
1	"	Glue.

Some inventors, thinking that coal does not contain sulphur enough and probably supposing that it improves the fuel, especially for metallurgical purposes, add to their mixture, as described in their specifications, large quantities of sulphur, some of them as much as three per cent.

A large number of patents have been granted in this country for artificial fuel. Most of them are modified copies of foreign patents, and a good number denote in their description a complete ignorance of the calorific properties of fuel and of the laws of combustion. The only one which, in my opinion, possesses real merit has been lately granted to Doctor Joshua R. Hayes, of Winchester, Pa. This patent was issued on March the 4th, 1873.

Mr Hayes uses coal dust, clay and asphaltum, but although the manner in which he combines these materials is new and ingenious, the product will be liable to the same objections made against the fuel manufactured in Europe from coal dust, clay and pitch, by Stafford, Oram, Goodwin, Geary and others.

The manufacture of artificial fuel, although being far from having attained the importance which it must attain in the near future, has been developed more rapidly in France and in Belgium than in England. English coal is harder than French and Belgian coal, and until within the last three years, the price of coal in England was so low that there was no inducement for capitalists to invest their money for the development of an industry which presented but poor prospects of good dividends. But increase after increase in the price of coal, during the last three years, has entirely changed the state of affairs. Large companies have been organized last year, with immense capital, for the manufacture of "patent fuel" by different processes. The last one patented in England, and which has also been patented in this country is the invention of Martin Rae of Uphall, North Britain.

It consisis in mixing with coal dust 15 per cent. of what he calls a bituminous *mastic*. This mastic is prepared in the following manner: Crude shale tar obtained in the distillation and refining of mineral oil from bituminous shale, is freed from sulphuric acid by means of steaming and washing in lime water. It is then run into a still, where the water and a portion of the oils is distilled off, which process renders the shale tar more dense and tenacious, being in a state between tar and pitch, (which is exactly the state of what is called fluid pitch).

A pipe from the bottom of the still conveys the mastic to a pan where the heat is kept up to about 200° Fahrenheit. From this pan the mixing machine, containing the coal dust mixed with about five per cent. of powdered clay, is supplied with the requisite proportion of mastic.

From the mixer the plastic mass is conveyed to a press, to be moulded, and from there to the drying oven. In this process we have again a mixture of clay, coal dust and some other bituminous material, fluid shale pitch.

A company was organized in May, 1873, with a capital of $1,000,000 under the name of the "Diamond Fuel Company," to apply David Barker's process.

In this process, a peculiar mucilage is mixed with the coal dust in the proportion of two ounces of mucilage to one pound of coal dust. The mucilage is manufactured in the following manner: One part of farina from which the gluten has been removed and which consists entirely or almost entirely of fecula or starch, is mixed with twenty parts of water, and to this is added a solution of sulphate of alumina or of chloride of alumina in hydrochloric acid, in the proportion of one ounce per gallon. The mixture thus formed is conveyed into a tank heated by steam, in which it is boiled and then run off, through a tap, into a boiler in which are placed pitch and carbolic acid, in the proportion of eight parts of the former to two of the latter. The whole contents of the boiler are subjected to the operation of boiling under moderate pressure, by which treatment the several substances contained in the boiler are caused to unite. Steam is then turned on into the boiler, and the contents thereof forced through pipes into a tank, whence the liquid is conveyed to the mixer by means of elevators, cased with sheet iron and wood, between which steam is introduced to keep the liquid from solidifying. In the mixer the coal dust is conveyed by a separate set of elevators, and is thoroughly amalgamated with the above described compound. The mixture is then compressed into lumps and dried in an oven.

It will be observed that in these two processes, as well as in the old one of cementing coal dust with pitch, or rosin, or asphalt, a large amount of natural coal is consumed, not only to dry or carbonize the product, but also to heat the cement and the coal dust itself. If the dust was not heated, the cement would not adhere to the particles of coal. There is also the unnecessary handling in carrying the fuel to the drying oven and removing it when dry.

Both Martin Rae and David Barker are inventors, not only of the process, but of the machinery for its application.

The mixing machines in Europe are almost all constructed on the same plan; they consist of vertical or horizontal cylinders, differing only in diameter, in height, or in length. In the centre revolves invariably an upright or horizontal shaft, to which are fastened, by set screws, a series of knives, blades, arms or paddles, set at a certain angle to force the materials downward or forward. To prevent the cooling of the materials, all the mixers are either surrounded with steam jackets, or furnished with openings, to which are adapted steam pipes to convey steam into the mixer. Some of those mixers have steam passing through the shaft and even through the arms or paddles. No improvements, worth noticing, have been made in the mixing apparatus for the last 40 years, while the compressing machines have been improved from year to year. This singular fact was noticed by Mr. L. Gruner, who, in a very elaborate article on artificial fuel, published in 1865, said that "it was to be regretted that the efforts of inventors had been almost exclusively directed towards improving the compressing machines." He had no doubt that if the mixing of the materials was more complete, if they should remain longer in the mixer, the proportion of cement, no matter what that cement should be, could be reduced considerably, which would, as a natural consequence, reduce the cost of fuel. To attain this very desirable object, he suggested an increase in the diameter of the mixer. The suggestion was a good one, still no improvements were made. I have seen at Bouffioulx, Belgium, a vertical mixer, about 20 feet high; it was calculated that with such a mixer, the materials would remain in the apparatus about half an hour, instead of ten minutes and sometimes less, as they did before. The pressure of the column of coal dust was so great that, when the power was applied, all the arms broke off one after another, except the six upper ones. This mixer was then replaced by an horizontal cylinder, forty feet in length. It worked better than the former, but the mixture not being plastic enough, two horizontal mixers were placed above one another. The materials falling into the hopper of the first one, would travel the entire length of said mixer and be discharged into the hopper of the lower one, at the end of which the materials would come out in a perfect plastic state and ready for compression. At Montigny-sur-Sambre, Belgium, Mr. Dehaynin used an horizontal mixer about 65 feet (20 metres) in length, heated all around; it may be imagined what trouble it must have been to keep such an apparatus in good working order.

Although the compressing machines used in Europe are numerous, they are all modifications of four distinct mechanical modes of applying pressure. First, by means of rollers; second, by pistons in closed moulds; third, by pistons in open moulds, and fourth, by pistons pressing cylindrical lumps with a hole through the centre.

Under the first-class, we have the following machines.

An endless chain, carrying moulds, working horizontally on a long table, passes under a hopper, from which sufficient material in a loose state is supplied to the moulds, to obtain lumps of a given density when compressed. These moulds pass under a roller, which revolves in an opposite direction and forces the loose materials into the moulds. The lumps are then discharged from the moulds by a piston. This machine was also invented by Bessemer and has been in operation in England and in France to make bricks.

Another machine has two rollers, revolving in opposite directions, one of which has on its face square cavities with movable bottoms, the face of the other roller being smooth. The plastic mass, fed between the rollers from a hopper above, is forced by the smooth roller into the cavities of the other one. At the lowest point of the course of this last roller, the movable bottoms are pushed forward by an eccentric, and the lumps being relieved fall on an endless belt, from which they are taken by hand and piled up in cars to be dried. This is more a moulding than a compressing machine. It was the invention of a German named Milch, and has been in use at Halle, Germany, to press lignite.

A third machine, invented by Mr. David, of Havre, has also two rollers, one of which has, like the preceding one, square cavities with movable bottoms, while the other one has projections which exactly fit those cavities. The plastic mass is forced into them by those projections, and at the same time, by an ingenious device, the bottom of each mould is alternately pushed forward a certain distance, so that the materials are pressed on both sides. An eccentric, as in Milch's machine, pushes the bottoms of the moulds far enough to relieve the lumps which fall also on an endless belt. The removal of these lumps and their drying is done by boys, who receive them in baskets as they fall from the endless belt. This machine is in operation at Montchanin, Brest, Caen, and Havre.

A fourth machine, the invention of Mr. Jarlot, of Lorient, France, has two very peculiar rollers. Their thickness is about three inches. To one side of each is bolted a cast iron cylindrical ring eight inches in

thickness and eight inches face. Through that thickness are bored, at certain distances, cylindrical holes, of larger diameter on the face and gradually reduced about one-tenth at the other end. The rollers are so placed that, when they revolve in opposite directions, the solid space between the openings of one roller exactly meet the openings of the other. A certain quantity of plastic mass is thus forced alternately in the openings of each ring, and the fresh materials forced in push forward towards the end of the opening, the coal which it contained already. Pressure in this machine is produced by friction of the materials along the sides of the openings. At each revolution of the rollers some more material is forced in, and the pressed fuel gradually emerges inside the ring, in a continuous cylindrical shape. When it is projecting a certain length, a stationary knife, which can be adjusted, cuts it off, and the lump falls along an incline planed into wire baskets, to be carried to the drying oven. This machine is in operation at Languin and at Bordeaux, France.

There has also been in use, during a few months, with very poor results, a machine invented by Mr. Verpilleux, of Rive de Gier, France. He used two smooth rollers, one of which was adjustable, so as to separate it from the other at any desired point. The plastic mass passed between these rollers as a thick band and was cut into sections by a revolving knife, placed underneath. This was simply laminating but not compressing.

I have described Martin's and Baudry's machines at length. As you will remember, they use two rollers having on their peripheries one-half of an ovoid or egg-shaped mould. It is on the principle of these machines that my press is constructed.

The following are among the inventors whose machines, compressing by a piston in a closed mould, belong to the second class, viz: Marsais, Poplin Ducarre, Moreau & David, Middleton, Mazeline & Couillard, and Revollier.

Marsais compresses the coal, by hydraulic pressure, into large and very heavy square moulds. These moulds have lids and also movable bottoms. When filled with the materials the lids are bolted to the moulds, and these are carried under an hydraulic press. The movable bottom is pushed upward and compresses the contents of the mould against the lid. A safety valve opens when the pressure exceeds certain limits. The lid is then removed, and the mould is carried under another press, which pushes the movable bottom upward with the lump on it. This lump is placed on a car and carried to the

drying oven. It requires ten minutes to mould one lump, which weighs about 465 kilograms or very near 1000 pounds. After being dried it is broken to pieces with hammers. In breaking it a large amount of the fuel is again reduced to dust.

Poplin Ducarre's press, like that of Moreau & David and others, is composed of a series of pistons, placed vertically or horizontally, pressing the coal into a series of moulds placed in the same way. When the pressure is applied by vertical pistons, there are two series of these working alternately; one to press the coal and the other to push the lumps out of the moulds. The frame containing the moulds is movable, and is placed on a stationary perforated table. When the coal is pressed and the compressing pistons have left the moulds, the frame which holds these moves sideways, so as to bring the bottom opening of the moulds exactly over the perforations of the stationary table. The lumps are then forced out of the moulds through those perforations by the other pistons. The moulding frame returns to its place, and the same operation recommences.

This machine is only used for the manufacture of what is known as "Charbon de Paris." The materials are charcoal dust, saw dust and coal tar. The lumps are cylindrical.

When the pistons are placed horizontally, the moulds remain stationary and the materials are pressed against strong movable gates. In this case we have a double set of moulds and pistons, and the same pistons both compress and discharge the lumps. The mixture, which fills the moulds from hoppers or from chutes communicating with the mixing machine, is first pressed against the gate of one side, which moves up and down in front of the moulds, and by a further pressure the lumps are discharged, while the gate comes down. During this operation the gate on the opposite side comes up and the moulds are filling. The same operation is then repeated by the other set of pistons. Both sets are worked by a yoke and cams. This model, although having only one mould on each side, can give you an idea of that kind of machine.

A serious defect of these presses is that the pressure is not gradual, but is given by a sudden blow. The feeding being very irregular, the lumps have not a regular density. Their production does not exceed 25 tons per day, the lumps weighing four pounds each.

Machines constructed on the same principle and which I have found, by personal experiments at Nesquehoning, to possess the same defects, have been patented in this country by John B. Collen and by T. M. Mitchell, both of Philadelphia.

The presses of Middleton, Revollier, and Mazeline & Couillard, have a solid circular turning table, containing a series of square moulds. While the table is revolving, the moulds pass in succession under a mixer or pug mill from which they are filled. In the centre of this mixer or pug mill is an upright shaft, to which are fastened, by set screws, and at any desired angle, a series of knives, which mix the materials and force them downward.

In Middleton's press, this turning table is placed so as to rest upon a stationary one, having the same diameter. The stationary table serves as bottom to the moulds of the turning one and has only one large square opening, through which each lump is discharged. The motion imparted to the moulding table is intermittent. The moulds are successively brought under a pug mill to be filled, then under a piston which compresses the materials against the stationary table, and finally under a second piston, which forces the lump out of the mould, through the opening described before, so that, while one mould is being filled, a lump of artificial fuel is pressed and another one is discharged. This press, which was at first adopted in all the Belgian factories, has a great defect. The jerking motion of the turning table has to be regulated with the greatest precision, so that the compressing piston and the discharging one exactly meet the moulds. The slightest deviation would break the piston rods. Middleton's press has been replaced everywhere in France and in Belgium by Revollier's press for a large production, and by Mazeline & Couillard's press for a small one.

In Mazeline & Couillard's press the moulding table revolves continually. In each mould is a movable bottom, having a small roller under it. These bottoms travel on an inclined helicoidal plane. Whenever a filled mould passes under a strong cast iron block, the bottom gradually comes up the incline plane and compresses the materials against that block, and while the rotary motion keeps on, the lump is gradually brought to the surface of the moulding wheel. At this point a scraper, worked by an eccentric, pushes the lump on an endless belt and springs back to push off again the next lump, and so on. The bottom of each mould gradually comes down and leaves room for the plastic mass to fall into it from the mixer. The lumps weigh about 20 pounds; as the moulding table contains 10 moulds and makes $2\frac{1}{2}$ revolutions every minute, the production is from 13 to 14 tons per hour.

These machines are in operation at Blanzy, Anzin, Valenciennes

and Havre, in France, also in England, Germany, Belgium, and even in two factories erected last year in Spain.

Mr. Revollier compresses by hydraulic pressure. The moulding table of this machine is about 10 feet in diameter, and is divided in four sections, each one of which contains a certain number of moulds, according to the size desired; in each mould is an independent movable bottom. During each revolution the table stops four times. The moulds of one section are all filled at the same time; the table then makes one-fourth of a revolution and brings that section under a strongcast iron block and over the pressing plate. This plate forces all the movable bottoms upward, compressing the coal contained in the moulds against the block. Another fourth of a revolution brings that section over a second plate, which works upward in the same manner as the pressing plate, and forces all the lumps out of the moulds at one stroke; where the moulding table completes a revolution, the lumps are placed in front of a scraper, worked by an eccentric. This scraper comes forward and pushes all the lumps at once on an endless belt, from which they are taken by boys. Although this seems to be a very slow method of compressing coal dust, the production exceeds that of Mazeline and Couillard's press, because each stroke of the piston makes 20, 30, and even 40 lumps, according to their size. The press is so constructed that the moulds can be changed at will, when larger or smaller lumps are required for the market. The production of this press varies from 20 to 25 tons per hour.

Bessemer's first machine, by which the coal dust, heated to a plastic mass, was forced through a long tube, belongs to the third class of presses. As I have said before, the tube was reduced in length and increased in thickness, on account of its bursting very often.

Mr. Evrard improved Bessemer's process in this manner. Sixteen cylindrical moulds are placed horizontally on a turning table, as the radius of a circle; each mould contains a piston and is open on top sufficiently to receive the plastic mass from the mixer, while it passes under it. The pistons are worked by means of a strong eccentric and of 16 short links. The cylindrical end of the moulds is formed by two semi-cylindrical sections screwed together, so as to allow some space between them, if necessary. At each stroke of a piston, a small lump is pushed out of the mould. The pressure is applied gradually and, as a consequence, the lumps are solid and have no cracks.

These machines are in operation at La Chazotte, La Grand Combe, France, and have also been tried by Mr. Dehaynin at Montigny-sur-sambre, Belgium, but their production being very limited, Revollier's press was preferred.

Mr. Moreau, of Paris, manufactures cylindrical lumps by using a horizontal cylinder, slightly conical at the end. In this cylinder revolves a screw which pushes the materials, falling into the cylinder from a hopper placed above it, towards the conical end, and forces the plastic mixture out through a small cylindrical opening. As fast as the pressed fuel emerges from the cylinder, it is cut into sections of any required length by a revolving knife. This is an imitation of a machine invented by Mr. Devinck, of Paris, for the manufacture of chocolate sticks.

The fourth class includes different apparatus which are simply modifications of machines used in the manufacture of hollow bricks and of drain pipes. Mr. Dehaynin, tried in his factory of Montigny-sur-sambre, a machine of that kind, patented by a Mr. Bourrier. The results were not favorable. Mr. Dehaynin has been the most persevering man in the artificial fuel industry. He has encouraged inventors in that line, tried their machines and has furnished a great many with the means for experimenting. He is to-day the proprietor of four establishments, in which 1,500 tons of artificial fuel are manufactured daily for the railroads and for the French navy. He has acquired immense wealth and he certainly deserves it.

Most of the machines which I have described have also been tried to convert peat into a dense fuel. Some of them have answered the purpose very well—Milch's machine, for instance. Large peat factories are in operation at Stalbach, Halle, Haspelmoor and Neudstadt, in Germany, and at Montangin in France.

I have derived very valuable information on the subject of artificial fuel from Messrs. Gruner and Gerondeau's works, from Armengaud's publications, from several European scientific publications, and especially from the Philadelphia Journal of Industry published in 1870 by Henry Howson, the well-known patent attorney.

Having given you a summary description of the different processes and of the machinery used for their application, I will now proceed to describe what appears to be their deficiencies.

It is evident that no artificial fuel containing a resinous substance will ever be used for demestic purposes, on account of the smoke and of the bad odor. Another objection is that such a fuel is liable to

spontaneous combustion. No objection of the kind can be raised against artificial fuel cemented with clay and milk of lime.

By mixing the coal dust and the cement in a vessel which contains only one single shaft with blades the materials are turned around, always in the same direction; it takes a long time before they are brought to a plastic state. Increasing the length or the number of horizontal mixers requires too much valuable space and is very expensive. A better result would certainly be obtained if the diameter of a vertical mixer was increased and if several upright shafts commanding each other and consequently revolving in opposite directions, were used instead of a single one. The knives of these shafts crossing each other in all directions, would undoubtedly perform a quicker and better work than the blades of one single shaft. Practical experiments have demonstrated this fact.

T. M. Mitchell, of Philadelphia, the patentee of different machines erected at Nesquehoning, Carbon County, Pa., used a vertical mixer with four shafts, which worked very well. It had, however, some defects. There was no possibility of ascertaining if the mixture had acquired a sufficient degree of plasticity, and when the mixer had to be cleaned, or some obstacle had to be removed from it, or some arm broke and had to be replaced, the whole machine had to be taken to pieces, which occasioned much trouble and a considerable loss of time. Still it was a decided improvement on all the European mixers. It is with that apparatus that I succeeded in reducing the proportion of clay to five per cent.

In my process, I use the slack without heating it or drying it previously. The moisture which it contains varies with the state of the atmosphere. Therefore I am compelled to regulate the supply of lime water accordingly. The difficulty of ascertaining the state of the materials, inside the mixer, suggested the idea of placing sliding doors around it. These doors facilitate the cleaning of the mixer and the removal of stones or pieces of iron which are found quite often in the coal dust. By means of a movable spider, which allows the removal of each shaft without interfering with the others and without removing the stationary frame in which they stand, a broken arm or a worn out one can be replaced by new ones in half an hour.

Although the compressing part of some only of the European presses is defective, the feeding part of almost all of them is very deficient. The materials to be pressed containing at certain times more moisture than at other times, the feeding of these materials to

the press ought to be reduced or increased accordingly, and, to effect that purpose, simple and efficient means are necessary.

The pressure should be applied gradually in order to expel, as much as possible, the moisture contained in the mixture and avoid cracks, which are the unavoidable result of a sudden pressure. An excess of compression spoils the fuel, prevents its free burning, and makes the ashes adhere to the surface of the lump, instead of falling through the grate into the ash pan. The fuel must be sufficiently compressed to bear transportation and reasonable handling and be still porous enough to insure free combustion.

The shape of the fuel is also of great importance. Square lumps have too many sharp edges which break off easily when the coal is handled, and the flat surfaces meeting very often in the fire prevent the free access of the air. Cylindrical-shaped lumps are better, still they have sharp edges left. Round or egg-shaped lumps are evidently to be preferred. It is not without some good reasons that this shape has met with favor for nearly three centuries in Europe.

To compress the plastic composition into round or egg-shaped lumps it requires less power than is required to compress square ones of the same weight, as there are no corners to fill and, as a result, less friction. With round or egg-shaped lumps, no matter what amount of coal is piled on the fire, there is always sufficient space between the lumps to secure a good draft and to allow a free access for a good supply of oxygen.

For these reasons I have adopted the egg-shaped form, slightly flattened, and have modified Baudry's and Martin's presses, in order to obtain more and better products. Instead of using moulding rollers producing only *one* lump at a time, I increase the length of the rollers and mould fourteen lumps at a time. The feeding is regulated by a pug mill, with a central shaft to which a series of knives is fastened at any required angle, and below these knives, on the same shaft, is a two-bladed propeller. The bottom of this mill is formed by two sliding plates, which can be brought apart and together by hand-wheels. I am thus enabled to increase or reduce the open space between them, and to force more or less plastic material between the rollers, according to the degree of moisture which it possesses. The number of revolutions of the knives can also be increased or reduced by changing one gear wheel, which can be done in a few minutes. A machine is thus obtained, possessing all the good qualities of Baudry's press and having none of its defects. The lumps

fall on an endless wire cloth belt and are carried by it directly into the drying oven. This press will produce over ten tons per hour.

The drying of the fuel, in Europe, takes place in ovens. As I have said before, it falls into baskets, or on trays, or is piled up into iron cars having perforated sides and bottoms. Although it requires much unnecessary handling, it must be admitted that with lumps of a considerable size, which remain a long time in the oven before drying, it is a necessity to adopt that system. When large sized lumps are piled up into a car, sufficient space can be left between the lumps to allow a free circulation of the heated atmosphere, but with lumps of a small size this system will not answer, and that for obvious reasons. If the cars are filled, the lumps at the bottom are crushed by the weight of the coal piled on top. The heated air cannot circulate between the lumps. The coal at the bottom, along the sides, and on top of the car will dry, while the centre of the mass retains the moisture. Sometimes, as it happened to me twice at Nesquehoning, the coal at the bottom of the car will catch fire, while the fuel in the centre is still moist.

To avoid the piling up of the coal in cars, and to give to each lump the full benefit of the heated atmosphere of the oven, I place five wire-cloth endless belts on the top of one another, leaving sufficient space between them. The belts command each other and they travel, in opposite directions, the entire length of the oven. The top belt comes directly from the press, with the pressed fuel on it, and it travels the entire length of the tunnel, at the slow speed of 12 feet in a minute; five times in succession is the coal carried through the tunnel, falling along chutes from one belt to the other, and it comes out on the fifth and lowest belt perfectly dry. The length of the oven is 100 feet.

The wire-cloth belts are strengthened by wire ropes, placed under them and in the centre. The wire-cloth is fastened to the wire rope by iron balls, cast in two pieces, each half having a recess for the wire rope to fit in; one of these half spheres receives the wire rope first, then the wire cloth is placed over it, and finally the other half is placed on the wire-cloth and the whole is solidly fastened together by a bolt which passes perpendicularly through the balls. These balls act like the cogs of a cog wheel, and run in a gutter placed under the centre of each belt, thus supporting the weight of the belt and of the coal on it. Each roller has four recesses in which the balls successively fall, thus preventing the slipping of the belt.

In this system all handling is suppressed. No cars, tracks, hooks, turning tables, etc., are necessary. The doors of the oven are always closed and consequently the heat in the oven can be kept up to any degree; the iron in the oven is not liable to contraction and expansion and less coal is consumed to dry the manufactured fuel.

To render the fuel impervious to moisture, instead of mixing a resinous substance with the materials, the lumps are simply dipped into a liquid composed of rosin number three dissolved in crude benzine. By exposure to a current of air the benzine evaporates, and leaves each lump coated with a thin film of rosin, which closes all the interstices and renders the fuel waterproof. I have kept lumps under water for three months. Here are some which have been kept for two months in this glass vessel at the American Institute Exhibition in New York. The only effect of the water on the coal is to turn the varnish with which it is coated to a greyish color.

This working model of my machinery will explain the entire process. The coal dust is dumped on a platform and pushed into the hopper of a stationary cylinder, in which revolves a shaft having six radiating partitions, dividing the interior of the cylinder into six equal parts. The coal dust falls between the partitions as they revolve and fills the whole space between them. The rotary motion given to the partitions carries the coal to an opening under the cylinder, where it is discharged. A smaller hopper receives the clay, previously dried and ground. This clay is carried through a smaller cylinder, containing also revolving partitions, and is discharged into the same chute as coal dust, with which it mingles. The space between the partitions of each cylinder are calculated so as to allow the discharge of only five per cent. of clay from the one, and ninety-five per cent. of coal dust from the other. The mixture of coal and clay, while falling under a chain elevator, is sprinkled, in due proportion, with milk of lime, from a tank placed at any desired point. This mixture is then raised, in a moist condition, by the buckets of said elevator, above the hopper of a conveyor in which it is discharged. A screw propeller, revolving in this conveyer, forces the materials into the mixer, where they are rapidly worked into a plastic mass by seven upright shafts. To each one of them, four-toothed arms are secured by set screws.

Through an opening in the bottom of the mixer the plastic mass falls along a chute into the pug mill of the press, and is forced by the knives and the two-bladed propeller between the rollers, where it is moulded into oval lumps which are discharged on the endless wire

cloth belt underneath the press. The lumps are carried by this belt into the drying oven, through which they travel five times, from one belt to the other. They come out on the fifth and lowest belt perfectly dried, and are discharged into the buckets of a second elevator, which carries them up and discharges them on the waterproofing belt. This belt is guided on each side by balls, and is continually immersing itself and the coal on it in the waterproofing liquid, contained in an open tank. On the sides of this tank are grooves describing a curve; under these grooves the balls travel. This tank is kept filled with the waterproofing liquid, supplied from a larger and hermetically closed tank. The belt has small partitions to prevent the sudden fall of the lumps into the mixture, and they also answer the purpose of raking them out of it. When the lumps come out of the bath, the liquid in excess pours in drops through the meshes of the wire-cloth into a gutter placed under it, and, through a pipe, is collected into any suitable vessel.

To evaporate the benzine the fuel coming out of the bath is discharged on the top belt of another oven, which I call the evaporating oven. This one is of smaller dimensions than the drying oven, and it contains only three belts, instead of five; they are also placed above one another. A fan forces air through this oven to evaporate the benzine, while the fuel is travelling from one belt to the other. From the third and lower belt the coal falls through a chute into the coal car standing outside. The end of the chute can be raised to allow sufficient time for the removal of the loaded car and the placing under the chute of an empty one. During this operation the fuel collects in the chute, so that there is no time lost.

From the moment that the coal dust and the clay are thrown into the respective hoppers of the distributing apparatus until the manufactured fuel falls, ready for the market, into the coal car standing outside, the whole process of manufacturing is carried on automatically. During the entire process the fuel is constantly in motion. With 14 men only, a production of 150 tons per day can easily be attained; two presses would be more than sufficient for such a production.

This model was built at the shops of Albright & Stroh, at Mauch Chunk, Pa., where I tried last week a small press constructed on the principle of the one I have patented. It worked to perfection and demonstrated conclusively the practicability of my process. These lumps, which are at your disposal, were manufactured at Albright & Stroh's by that machine. They are exactly of the shape and size which I have adopted for stove coal.

I was perfectly familiar with this artificial fuel matter when I came to this country. I knew the processes tried and applied in Europe, and also the machines which had been used for the application of those processes. I knew their qualities and their defects, and when my attention was called, six years ago, to the immenae accumulations of coal dust considered here as worthless, I concluded that I would benefit mankind and myself if I could make of that waste a marketable product.

I went earnestly at work. I met with difficulties of all kinds, pecuniary difficulties, popular prejudices, old-fogies ideas, opposition of coal dealers, opposition of coal miners; I even was called crazy by members of my own family. I often felt low spirited, but I must say that I was cheered up many a time by encouragements from intelligent and scientific minds.

When I came to Philadelphia, three years ago, I was told that this was not the place for me; that Philadelphians, as a mass, were lacking spirit and business liberality; that no new invention, and especially so in a case like mine, where so many had failed, would receive encouragement or support.

As this was merely an assertion I relied upon my own judgement and experience to find out if its truth was demonstrated by facts. The result of my observations was that Philadelphians were unenthusiastic and somewhat disinclined to accept any new matter on faith, but knowing that, as a natural result, it is characteristic of such a people to hold fast to faith, which they have once based on a conviction of merit, utility and profit, I determined to stick to my task and to remain here. I saw that mere novelty, or loud talking, or humbug of any kind, would not be sufficient to force a matter on the public, but that I had to give substantial evidences of the merits of my invention, of its thoroughness, of its vitality, in order to earn the confidence of Philadelphians.

I made an appeal to the highest scientific authority of this country, to the Franklin Institute of this city, to that institution of which I am proud to be a member and which never refuses to acknowledge an invention of merit. A committee was selected and a very favorable report was made on my fuel in December, 1870. This, after four years of struggles, was the first powerful lift which decided my success. The process was invented, but only part of the machinery for its application.

It is evident, that no matter its utility, its practicability and the

profits to be derived from it, an invention must not be presented to the public too hastily, before it has been well digested or before means have been considered to carry out the proposed end. The inventor must be able to tell to the public not merely that a certain good and profitable object is in view, but that an intelligent plan has been devised for attaining that object, and that the execution of that plan is practicable, that it will benefit the people at large, and also, at the same time, secure remuneration on the capital invested.

To do this I required help, and substantial help. The Lehigh Coal and Navigation company of this city, at the suggestion of its honorable president, Mr. E. W. Clarke, furnished me with all the means, mechanical and financial, to experiment upon my process. This enabled me to study the matter practically, to ascertain the difficulties which I was exposed to meet in the future, and to modify my machinery in order to avoid those difficulties. For this help extended I publicly express gratitude to the Lehigh Coal and Navigation Company, with whose President and officers generally my relations have been most pleasant and agreeable.

I owe also a dept of gratitude to the Press of this city. Publication of the report of this Institute, with very flattering and encouraging editorial comments on my process have been published in the Philadelphia papers. These articles, republished all over the country, have given to my process the notoriety which it has acquired.

To-day, I am glad to say, these experiments are satisfactorily finished, and the product, I believe, will shortly become a commercial article.

The following figures give the quantities of coal raised in Great Britain, with the loss of life which took place for each year, from 1868 to 1872:—

Date.	Tons of Coal Raised.	Deaths.	Tons of Coal Raised per Death.
1868	104,566,959	1011	103,429
1869	108,003,482	1116	96,777
1870	112,875,525	991	113,900
1871	117,439,251	1075	109,246
1872	123,393,853	1060	116,400

The chances of a collier's life may thus be accurately calculated according to the duantity of coal raised, the rutio being closely preserved year after year with dreadful regularity.

ON A NEW ALLOTROPIC MODIFICATION OF PHOSPHORUS.

By Prof. Edwin J. Houston.

In connection with Prof. Elihu Thomson, of the Artizans' Night School, the author has undertaken an extensive series of experiments, resulting, it is believed, in the discovery of a new allotropic modification of phosphorus.

It has long been known that when phosphorus is boiled in strong potassium hydrate, and then allowed to cool slowly, it retains its liquid state for some little time, but that if shaken, or touched by a sharp point, instantly solidifies.

We believe that in the cases heretofore observed, the property of retaining the liquid state, may be owing to the admixture with the ordinary phosphorus of an allotropic modification, having the property of retaining its liquid state indefinitely. Hence, if this modification be obtained sufficiently pure, it would probably exhibit properties strikingly distinct from the common variety. We have therefore instituted a series of experiments, with the following results.

Good phosphorus was taken and boiled repeatedly in strong solution of potassium hydrate, water being occasionally added to replace that lost by evaporation. Care was taken by cautious stirring to prevent the phosphorus from being carried to the surface, by bubbles of the disengaged gas. When the operation had continued for five or ten minutes, the liquid phosphorus was carefully washed by replacing the alkaline solution by a stream of running water. In this way, all the hypo-phosphites were removed, as well as the liquid and gaseous hydrides of phosphorous. The purified liquid phosphorus is now in a condition, which we believe to be a new and hitherto unnoticed allotropic modification. It has the following properties.

1st. That of retaining for an apparently indefinite time its liquid condition, even when exposed to temperatures very considerably below the melting point of ordinary phosphorus. A carefully prepared specimen has been kept by the authors for upwards of *four months*, and is still, at the date of this publication, in the liquid condition. The specimen in question is preserved beneath a water surface in a small test tube. Its weight is about one-eighth of an ounce. The test tube is tied by a string and suspended in a position where it is free from jars or sudden shaking. The room in which it is preserved has been for weeks without a fire, the temperature having often reached a point probably near 40° F., and yet the liquefaction has not been dis-

turbed. There is every reason to believe that this specimen in common with others experimented upon, will instantly solidify on being touched.

A small specimen placed in a test tube and covered by a water surface, was exposed to artificial cold, produced by the rapid evaporation of ether. It solidified at about 38° F. Under more favorable conditions, and with larger masses, it is probable that the temperature could be reduced still lower.

2d. Another respect in which this liquid differs from the ordinary variety is in its non-oxidation on exposure to the air.

3d. It does not shine in the dark. This follows from the preceding property. Several specimens showed no appreciable light when exposed to direct contact with air in a dark room. We regard this very unusual property as suggestive of an allotropic state.

Apparently two modifications of solid phosphorus result from the solidification of the liquid variety. One is tough and waxy, like ordinary phosphorus; the other brittle and crystalline in texture. The best liquid specimens in solidifying, always gave the second variety—indifferent ones, the first. We therefore regard that producing the second, as the true liquid modification.

Rough experiments were made in order to ascertain whether the liquid modification underwent any change in volume by solidification. For this purpose a specimen was placed in a test tube filled with water, and a small capillary tube also filled, passed down into the vessel, and attached to it by a well-fitted cork. Any appreciable change in the volume of the phosphorus would cause a rise of the water in the capillary tube. We expected to find a slight change, but none was observable. This result was probbaly owing to the expansion occasioned by the heat emitted on solidification, exactly balancing the contraction caused by the passage from the liquid to the solid state. No sudden movement of the capillary column was noticed on the instant of solidification.

In order to see whether the liquid state was due to hydrogen in combination with the phosphorus, we placed small pieces of the solid varietyin a tube, whose ends were afterwards drawn out into capillaries, and then, passing hydrogen from a small generator through the tube, melting the phosphorus. A liquid resulted, possessing different properties from that formed by boiling in potassium hydrate. It was quite mobile, of an amber color, and on solidifying, produced the waxy material.

A fact not perhaps well known, was noticed during the conduct of the experiment. A colorless gas was evolved from the free end of the tube which was spontaneously inflammable in air. The heat of this flame was, however, so slight as to render it incapable of igniting the hydrogen issuing with it.

To test the effect of the boiling point upon the production of the allotropic modification, specimens were prepared by long boiling in saturated solution of chloride of zinc. We were unsuccessful in obtaining the liquid modification. A high boiling point cannot, therefore, be assigned as the entire cause of the change.

The substance in question may be merely a very pure phosphorus, yet its liquid condition and non-oxidation can scarcely be ascribed to this circumstance. We therefore consider that the existence of a hitherto unknown liquid modification of the element phosphorus is rendered highly probable. The distinct properties it possesses, apart from the ordinary substance, are much more clearly marked than those upon which the elastic modification of sulphur is based.

It may be mentioned incidentally that the brittle crystalline mass, produced on the passage of the liquid modification to the solid state, differs from the waxy variety of ordinary phosphorus. It oxidises so rapidly on exposure to air as to produce a rise of temperature sufficient for its liquefaction. The liquid thus produced possesses only the properties of ordinary melted phosphorus, and catches fire very readily.

Central High School.

Franklin Institute.

Proceedings of a Special Meeting, held November 10, 1873.

Special meeting of the Institute at the call of the President.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The President stated the object of the meeting to be, to permit the members in attendance to listen to the reading of a paper by Mr. Fred'k Ransome, of England, "On some recent Improvements in the manufacture of Artificial Stone;" and to afford them opportunity for discussing the same, and directed the Secretary to read the application, in virtue of which the special meeting had been called. The Secretary thereupon read an application, signed by twelve members of the In-

stitute, requesting the President, by the authority vested in him by Sec. 2 of Article XII, of the By-Laws, to call a special meeting of the Institute for the purpose specified above.

The President stated, the requisite formality having been complied with, he had authorized the meeting for this evening; and thereupon introduced Mr. Ransome to the meeting.

After the reading of the paper and the discussion thereon, which will be found published in full in the JOURNAL of December, 1873, Mr. Washington Jones moved that the thanks of the meeting be tendered to Mr. Ransome for the interesting and instructive paper which had just been read. The motion was unanimously carried, and the President expressed the sentiment of the meeting to Mr. Ransome. In reply, Mr. Ransome expressed his obligations to the members for the courtesy and attention with which he had been received.

The meeting was then, on motion, adjourned.

WILLIAM H. WAHL, *Secretary.*

Proceedings of the Stated Meeting held November 19, 1873.

The meeting was called to order at the usual hour.

In the absence of the President, Mr. J. E. Mitchell was called upon to preside.

The minutes of the last stated meeting were read, as also the minutes of the special meeting held November 10th, and were approved.

The Actuary submitted the minutes of the Board of Managers, and of the several standing committees; and reported that at the stated meeting of the Board held November 12th, donations to the Library had been reported from the following sources, as below.

Annales des Ponts et Chaussées, for May, 1873; from the Editor, Paris.

The Locomotive Engine, and Philadelphia's share in its early improvement; from Joseph Harrison, Jr. Philadelphia, 1872.

Metallic Cartridges, as manufactured and tested at the Frankford Arsenal, Philadelphia, Pa. Washington, D. C., 1873. From Major T. J. Treadwell, Ordnance Department U. S. A.

Compagnie Generale pour le curage et l'entretien des Fleuves et des Ports. From J. E. Mitchell, Esq., Philadelphia.

Bulletin of the National Association of Wool Manufacturers, July to September, 1873; from the Association.

Report of the Board of Commissioners of the third Cincinnati Industrial Exposition, 1872; from the Commissioners.

Report of the Commissioner of Education, for 1872; from the Commissioner. Washington, 1873.

The Coal and Iron Trade; embracing Statistics of Pennsylvania, &c., in 1847; from S. C. Bruce, Esq.

Report of the Director of the New York Meteorological Observatotory; from the Director. Albany, N. Y.

A Treatise on Machine Tools, &c., as made by William Sellers & Co., Philadelphia, Pa.; from the firm.

First Annual Message of William S. Stokley, Mayor of the City of Philadelphia, with accompanying documents. June 26, 1873. From his Honor, the Mayor.

Belting Facts and Figures. By John H. Cooper, Esq. Philadelphia, 1873. From the Author.

The several special committees of the Institute reported progress and were continued.

In connection with the reports of the committee on the mode of determining the horse-power of steam-boilers, presented and ordered to be published in the JOURNAL, at the last meeting, the Secretary stated that some difference of opinion existed in the minds of several members who had been upon the committee, as to the proper mode of designating the reports in question, and asked for instructions upon this point. The Secretary also read a preliminary introduction which he had prepared to precede the reports, in the Journal.

A motion of Mr. Edward Brown, that the introductory, as read by the Secretary, be inserted in the Journal before the reports, was adopted.

(The reports, with the introductory as ordered, will be found in the Journal for December, 1873.)

The chairman next announced a paper by Mr. J. Luther Ringwalt, on a new process of Engraving. The speaker illustrated his paper by distributing, with other prints, one engraved and printed in the presence of the audience. The paper will be found in full in the Journal for January, 1874.

Mr. Wm. B. Le Van next read a paper on a recent test of an Eberhardt boiler; also another on a recent disastrous steam-boiler explosion. The latter will be found in the Journal for January, 1874.

Mr. C. W. Hunt then read a paper on an automatic railway; a gravity road for the use of coal yards, furnaces, miners, etc., requiring neither steam nor horse-power. The paper will be found in the Journal for December, 1873.

The Secretary then presented his report. Under the head of deferred business, the Secretary called the attention of the meeting to the following from the minutes of the October meeting, viz:

"Under the head of New Business, the President announced the receipt of a communication, signed by sixteen members, requesting that the Library and Reading Room of the Institute be opened on Sundays between the hours of 10 A. M. and 3 P. M. The subject elicited considerable expression of opinion, which was participated in by Messrs. Orr, Le Van and Close. A motion to defer action on the subject until the November meeting, finally prevailed."

The chairman then announced that this subject, which had been deferred, was before the meeting, and added that he held in hand a paper signed by 42 members, requesting the opening of the Reading Room and Library on Sundays.

Mr. Chabot then offered the following:—

Resolved, That the Library of the Institute be opened on Sundays for the use of the members: seconded by Mr. Wm. B. Le Van.

Mr. Hector Orr opposed the resolution in a lengthy address, and closed by moving to amend the resolution by inserting after the word resolved, the following: "That the request of certain members asking for the opening of the Institute on Sundays, be referred to a special committee to be announced at the next stated meeting of the Institute, and be instructed to examine the entire subject, and report thereon to the Institute." Seconded by Mr. Chas. S. Close.

Mr. David Branson, after stating the amendment to be indefinite as to time, and that if it prevailed it would be practically an indefinite postponement of the subject, moved the following amendment to the amendment, viz: "That this committee shall consist of ten members, to be appointed by the President, to report on the subject at the next stated meeting, and that five of this committee shall be chosen from amongst the signers of the request." Seconded by Mr. H. B. Bartol.

Remarks upon the subject were offered by Messrs. Orr, Le Van, Chabot, John Sartain, Close, and others; finally, upon the question being put to the house, the amendment to the amendment was carried: the amendment as amended was carried, and the original resotion as amended was carried.

In virtue of the foregoing, the President has appointed the following gentlemen to serve as the committee, viz: David Branson (ch.); J. B. Knight, C. Chabot, John Sartain, S. F. Corlies, Hector Orr, Henry Cartwright, Fred'k Fraley, J. E. Mitchell, and B. H. Moore.

After the action upon the resolution and amendments, as above, the meeting adjourned.

WILLIAM H. WAHL, *Secretary.*

Proceedings of the Stated Meeting held December 17, 1873.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and of the several standing committees, and reported that at the stated meeting of the Board, held December 10th, the following donations to the Library were received, viz:

Notes on the form of Cyclones in the Southern Indian Ocean, and on some of the rules given for avoiding their centres. By C. Meldrum, Esq., M. A., F. R. S. From the Meteorological Society.

Public Ledger Almanacs for the years 1870 to 1873. From Geo. W. Childs, Esq., Philadelphia.

Annales de Chimie et de Physique for April to July, 1873. From the Publishers, Paris.

Bulletin de la Societé d' Encouragement pour l' Industrie Nationale, for December, 1872, and May, June, and July, 1873. From the Society.

Comptes Rendus, Nos. 13 to 26, Vol. 76, and No. 1 of Vol. 77, with Index for Vol. 75. From the Academy, Paris.

Traité des Derives de la Houille, etc. Par Charles Girard et G. de Laire. From G. Masson, Editor. Paris.

Annales des Ponts et Chausseés for June, 1873. From the Editor. Paris.

Jahrbuch der K. K. Geologischen Reichsanstalt in Wien, for January, February, and March, 1873. From the Direction.

Verhandlungen derselben, Nos. 1 to 6, 1873. From the same.

Uber einen neuen Fossilen Saurier aus Lesina. Von Dr. A. Kornhuber. From the same.

An Investigation of the Orbit of Uranus, with tables of its Motion. By Professor Simon Newcomb, U. S. N. From the Smithsonian Institution.

Proceedings of the Scientific Meetings of the Zoological Society of London, for 1872, part 3, June to December. From the Society.

Zeitschrift des Architehten und Ingeneur Vereins zu Hannover. Volume 19, part 1–2, 1873. From the Society. Hannover.

Journal of the Chemical Society of London, for October, 1873. From the Society. London.

Journal of the Statistical Society, for September, 1873. From the Society. London.

Journal of the Society of Arts of London, October 3d—31st, 1873. From the Society. London.

Chief Engineer's Monthly Report to the Manchester Steam Users' Association, for August and September, 1873. From the Association. Manchester.

Annual Report upon the Improvement of Rivers and Harbors in New Jersey, Pennsylvania, etc. From J. D. Kurtz, Esq.

The Actuary likewise reported the resignation of Messrs. Robert Briggs and William F. Durfee as members of the Board of Managers, and the following resolution of the Board. Resolved, that the Secretary be requested to write to Washington for information concerning a bill reported passed at a recent date, permitting steam boilers used on Western rivers with $\frac{1}{4}$ inch thickness of plates and 54″ in diameter, to carry 150 lbs. of steam, and that he be requested to report at the next meeting of the Institute.

The Special Committee on Conflagrations reported progress, and was continued.

The Special Committee to which was referred the request of certain members to open the Reading Room and Library on Sundays presented majority and minority reports: Mr. Henry Cartwright, on behalf of the majority, reported that the Committee had held several meetings, and had discussed the subject in all its bearings. They had decided to refer the subject back to the Institute with the recommendation that it be voted upon by ballot, at the same time as the holding of the annual election for officers, and that due notice of such election be given in the public press. Mr. David Branson presented a minority report, containing a *resumé* of the arguments *pro* and *con* which the subject had called forth, and recommended that it be made the subject of a special election by ballot, to be held on Monday, Tuesday and Wednesday, January 19th, 20th and 21st, 1874, from 10 A. M., to 10 P. M., after due notice to members by postal card, and advertisement of the fact in the public press.

The reports were accepted and the Committee discharged, and upon motion of Dr. Henry Leffmann it was resolved, that the proposition of the majority report, that the vote upon this subject be taken on the day of the annual election, be approved, and that for the special election the polls be open from 10 A. M., to 8 P. M.

Mr. Le Van moved that a special set of Tellers be appointed for the special election, and further, that the Secretary be instructed to give proper notice of the subject to be voted upon through the public press; carried.

Mr. Henry Ashford, of Philadelphia, next presented a paper descriptive of a self-releasing apparatus for boats.

Under the head of New Business, the President stated that nominations for officers for the Institute were in order, explaining that, according to the By-Laws, there were to be elected a President, a Vice-President, a Treasurer, and Secretary, to serve for the term of one year; eight Managers to serve for three years, and two to serve one year, and an Auditor to serve for three years.

In accordance with the foregoing, the following nominations were made:

For President.—Coleman Sellers.
" *Vice-President.*—Robert E. Rogers.
" *Treasurer.*—Frederick Fraley.
" *Secretary.*—William H. Wahl.

For Managers to serve three years.—J. E. Mitchell, F. B. Miles, E. J. Houston, William Helm, William B. Le Van, Samuel Sartain, Charles Bullock, Enoch Lewis.

For Managers to serve one year.—George F. Barker and Theodore D. Rand.

Auditor to serve three years.—William Biddle.

The President thereupon appointed the following members to serve as judges of the annual election for officers, viz:

George Gardom, Geo. R. Barker,
William A. Rolin, John W. Nystrom,
Hector Orr, James Cresson,
John Hoskins;

and the following to act as Tellers for special election, viz:—William Taggert, Theodore D. Rand and William H. Wahl.

Mr. Orr then, in appropriate words, called the attention of the meeting to the recent death of Professor Louis Agassiz, and concluded by moving the following: Resolved, That a committee of three members be appointed to frame a minute expressive of the sense of the Institute at the death of Professor Louis Agassiz. The resolution was carried, and the President designated the following named members to form this committee, viz:—Hector Orr, Dr. J. Gibbons Hunt and Bloomfield H. Moore.

The President then drew attention to the fact that, on the 9th day of December, 1823, the first meeting was held, which culminated shortly afterwards in the formation of the Franklin Institute; and that the first body of officers of the Institute were elected on the 6th of February, 1823. The President suggested the propriety of taking some notice of the interesting fact that the 6th of February next would mark the 50th anniversary of the existence of this Society. It was thereupon moved by Mr. Hector Orr, that a committee be appointed, of which the President be the chairman, to devise some method of properly celebrating the 50th anniversary of the organization of the Franklin Institute, and that this committee have the power to act. The motion prevailed. The President appointed Messrs. Coleman Sellers, Frederick Fraley, B. H. Moore, Hector Orr and William P. Tatham as members of the committee in pursuance of the motion. The meeting then adjourned.

WILLIAM H. WAHL, *Secretary.*

HALL OF THE FRANKLIN INSTITUTE,
Philadelphia, January 19th, 1874.

The Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred for examination Wm. M. Henderson's Hydraulic Brake, report, that we have examined said brake and found that it answered to the inventor's description and drawings, which we beg leave to submit in his own words.

The principle involved in the operation of this brake is that of hydraulic pressure, and the motive power is derived directly from the steam boiler of the locomotive. The apparatus consists of three devices: first, a two way cock; second, pressure boxes for applying the brakes, and third, a non-freezing attachment.

The two way cock is placed underneath the foot-plate of the engine, its plug operated by a stem carried up and furnished with a hand-wheel, or lever at top, placed convenient to the hand of the engineer. The branch marked 1 is connected by a piece of wrought pipe directly to the water space of the boiler; the opposite branch, marked 2, is connected by wrought iron pipe and flexible hose connections furnished with valvular couplings between the cars, and leads directly to the pressure boxes, placed at every truck; the third branch is connected directly to the water tank of the tender.

The pressure boxes are of the following construction: a cylindrical

vessel of cast iron is provided, about nine inches in diameter and three inches deep, with about a five-inch hole through it. Two flexible diaphragms of vulcanized india-rubber of disk-form are next introduced, back to back, leaving a space of about half an inch between them, when their flanges rest upon the box; these are secured in position by rings bolting through the whole, making an air-tight joint at the periphery. Into the interior of the disk-form diaphragms, are fitted two rams working in opposite directions, and these are attached by rectangular flanges and bolts to the brake beams carrying the brake shoes; guides are provided for supporting the central casting in position relative to the rams.

NOTE.—For Plate referred to in Report of Committee on Science and Arts on Henderson's Hydraulic Brake, see "Journal Franklin Institute," Vol. lxvi, 406.

it, opening towards the glycerin vessel, so that should a vacuity occur from accidental leakage, the loss will immediately be made good from the reservoir; a disposition of the fluid to return to the reservoir is instantly checked by the valves closing.

The operation is as follows: When the train is running, the play of the two way cock makes a communication between the tender tank and the pressure boxes (the non-freezing attachment being shut off), by closing the cocks E and F and opening G, and when the engineer desires to apply the brakes, he turns the plug of the two way cock so as to let the boiler pressure act upon the column of water in the main pipe the pressure is transmitted to the diaphragms of the pressure boxes, and, pressing them apart, the brakes are at once applied. To take them off, the engineer turns the plug of the two way cock back again. This shuts off the boiler, destroys the hydraulic pressure, the diaphragms collapse, and the surplus water is discharged into the tender tank without loss of substance or heat.

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Messrs. C[illegible]

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The non-freezing attachment is a cylindrical vessel made in halves and embracing at the joint, where it is bolted together, the flange of a double corrugated flexible diaphragm. This vessel is connected to the main pipe by a short tubular connection furnished with a stop-cock E. Leading away from the upper end of this vessel is another tube connection which makes an advanced connection with the main pipe, and is also furnished with a stop-cock F. Between the point of junction of these two connections there is placed another stop-cock G.

The non-freezing fluid, preferably glycerin and water in equal parts, which is safe to 30° below zero, is placed above the diaphragm; the pressure is applied below, and in order that the vessel shall remain at all times fully charged with the fluid, a reservoir I is provided on the tender containing an excess quantity. The pipe proceeding from the reservoir to the glycerin vessel has a check valve H fitted to it, opening towards the glycerin vessel, so that should a vacuity occur from accidental leakage, the loss will immediately be made good from the reservoir; a disposition of the fluid to return to the reservoir is instantly checked by the valves closing.

The operation is as follows: When the train is running, the play of the two way cock makes a communication between the tender tank and the pressure boxes (the non-freezing attachment being shut off), by closing the cocks E and F and opening G, and when the engineer desires to apply the brakes, he turns the plug of the two way cock so as to let the boiler pressure act upon the column of water in the main pipe the pressure is transmitted to the diaphragms of the pressure boxes, and, pressing them apart, the brakes are at once applied. To take them off, the engineer turns the plug of the two way cock back again. This shuts off the boiler, destroys the hydraulic pressure, the diaphragms collapse, and the surplus water is discharged into the tender tank without loss of substance or heat.